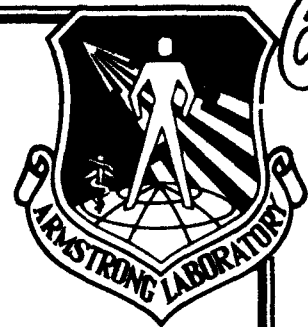


AL-SR-1992-0034

AD-A274 517



2

RECOMMENDATIONS FOR FUTURE RESEARCH ON  
HIGH ACCELERATION COCKPITS WITH ANNOTATED  
BIBLIOGRAPHY OF THE LITERATURE 1936-1992

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JULY 1992

FINAL REPORT FOR PERIOD JULY 1988 TO JULY 1992

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## TECHNICAL REVIEW AND APPROVAL

AL-SR-1992- 0034

The voluntary informed consent of the subjects used in this research was obtained as required by Air Force Regulation 169-3.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER



THOMAS J. MOORE, Chief  
Biodynamics and Biocommunications Division  
Crew Systems Directorate  
Armstrong Laboratory

## REPORT DOCUMENTATION PAGE

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## PREFACE

Support for this effort was provided by the Combined Stress Branch of the Biodynamics and Biocommunications Division of the Armstrong Laboratory at Wright-Patterson AFB, Ohio 45433-6573. The bibliographic portion of this effort has been adapted from work accomplished under the Biodynamics Databank Bibliographic Files, known until the time of its cancellation, as DB-56. The original material has been updated and separated into topical categories for the convenience of the reader. All material from DB-56 are unclassified/unlimited, although some of the actual reports may have limited distributions, which are noted in the bibliography, but none are classified.

Following the updating effort, each section was reviewed with the objective of defining areas of research requiring additional investigation. The reviews are presented at the beginning of each section where appropriate. The editor wishes to acknowledge the contributions of M. H. Maxwell and Dr. George Potor, M.D., for their previous effort in saving and compiling and editing the original DB-56 bibliographic files which made this effort possible.

This effort was funded under Project 7231, Task 25; Aircrew Performance Enhancement under Contract Number F33615-89-C-0574 with Systems Research Laboratories, 2800 Indian Ripple Rd., Dayton, OH 45440-3696.

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## INTRODUCTION

In July 1992, HQ Air Combat Command (ACC) issued a "prioritized user-focused" aeromedical research requirements list to HQ AFMC. This list of 37 items included 23 near term (next 5 years) requirements and 14 far term (5-10 years) requirements. Several of the requirements are addressed in this report including:

- Assess performance under high G loading (Ranked #2)
- Assess human capabilities in the over +9 Gz range (Ranked #15)
- Explore seat configuration technology for optimal G tolerance without degradation of mission capabilities (Ranked #16)
- Agile Flight: Explore human performance and tolerance in other than Z-axis for G (Far term requirement ranked #11)

The issues of high acceleration, the 12 G aircraft, and reclined seating for pilots are still pertinent, according to the 37 requirements from HQ ACC.

The objectives of this report are to assemble in one location the bulk of the literature pertaining to high acceleration cockpit (HAC) research, to review that research, and to define additional research that may be required to provide a basis upon which to consider the incorporation of the HAC concept into an operational aircraft.

Each section of the report begins with a review of the literature and recommendations are made for future research. Following each section, is an annotated bibliography of the high acceleration cockpit research literature. The time span of this bibliography runs from 1936 to 1992. Each entry in this annotated bibliography contains the following fields where appropriate:

- ACCESSION NUMBER: An identifying number assigned in the original database-for identification only.
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- SOURCE NAME: Identification of the organization that performed the work or the document in which the work was published.
- TITLE: Self-explanatory.
- PERSONAL AUTHORS: Self-explanatory: where only corporate authors are available, they are listed.
- REPORT DATE: Self-explanatory YY/MM/DD.
- PAGINATION: Number of pages in the document.
- REPORT SERIES NUMBER: An identifying number assigned by the SOURCE.

**SUPPLEMENTARY NOTE:** Identification of the type of document: usually a Technical Report or a Journal article.

**DIST/AVAIL STATEMENT:** Information on how to obtain the document.

**ABSTRACT:** Self-explanatory.

**RECOMMENDATIONS FOR FUTURE RESEARCH ON  
HIGH ACCELERATION COCKPIT CONCEPTS**

In the following sections, the published literature is reviewed with the objective of defining areas of research in which an insufficient amount of work has been done to answer the salient unanswered questions.

This task of definition was one of the primary objectives in the creation of this review, bibliography, and report. It is recommended that these observations on the unfinished work be disseminated among the research organizations active in this field in order to obtain their comments and contributions. In this manner, the structuring of any future program of research may be optimized.



## HIGH ACCELERATION COCKPIT RESEARCH

AERODYNAMICS  
SUPERMANEUVERABILITY/AGILITY  
FLIGHT CONTROL  
FLIGHT DYNAMICS  
AIRCRAFT MODIFICATION/FEASIBILITY

### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The important issues represented in this section consist of the new challenges presented by the Supermaneuverability/Agility concept, and the old issues of the influence of aircraft angle of attack and Z axis acceleration vector behavior on the configuration of the seat. These are both aircraft-specific issues and will have to be carefully considered in terms of: a) the likelihood that a HAC seat will be retrofitted to some specific aircraft, b) the case in which a HAC seat is to be incorporated in some future aircraft, including the F-22 and/or an agile aircraft. In either case, a knowledge of the pertinent aerodynamic behavior of the airframe will be required for intelligent research planning.

### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 47628

TITLE: TECHNICAL PROPOSAL FOR AFTI-16 PRE-DESIGN AND  
PRELIMINARY DEVELOPMENT OF DFCS & HAC, VOLUME 3-  
PRELIMINARY DEVELOPMENT OF HAC

REPORT DATE: 77/03/14  
PAGINATION: 75P  
REPORT SERIES NUMBER: FZP-1831-3

ABSTRACT: AFTI-16 MEANS ADVANCED FIGHTER TECHNOLOGY INTEGRATION-  
DEMONSTRATED BY MODIFICATION OF AN F-16. THREE TASKS, AFTI-16 PRE-DESIGN, THE  
PRELIMINARY DEVELOPMENT OF A DIGITAL FLIGHT CONTROL SYSTEM (DFCS), AND THE  
PRELIMINARY DEVELOPMENT OF A HIGH-ACCELERATION COCKPIT (HAC), CONSTITUTE THE  
AFTI-16 PHASE I PROGRAM. SUCCESSFUL COMPLETION OF THESE TASKS WILL DEFINE A  
CREDIBLE, COST-EFFECTIVE DEMONSTRATOR AIRCRAFT FOR AN INTEGRATED SET OF  
EMERGING TECHNOLOGIES. THIS TECHNOLOGY SET, DESIGNATED SET I, WILL ENHANCE  
AIR-TO-AIR AND AIR-TO-SURFACE COMBAT EFFECTIVENESS.

ACCESSION NUMBER: 89-454  
SOURCE NAME: U.S. NEWS AND WORLD REPORT

TITLE: TURNING ON A DIME IN MID-AIR: NEW FIGHTERS THAT BEND  
THE LAWS OF AERODYNAMICS

PERSONAL AUTHORS: COOK, W.J.

REPORT DATE: 89/02/20

PAGINATION: 5P  
SUPPLEMENTARY NOTE: MAGAZINE ARTICLE  
DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: ARTICLE INTENDED FOR THE LAY PUBLIC CONCERNING THE  
POTENTIAL OF NEW, SUPERMANEUVERABILITY AIRCRAFT CAPABLE OF MANEUVERING IN THE  
POST-STALL REGIME.

ACCESSION NUMBER: 4453  
AD: A  
AD NUMBER: 025083  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB,  
OHIO

TITLE: INFLUENCE OF AIRCRAFT ANGLE OF ATTACK ON HIGH G  
COCKPIT DESIGN.

PERSONAL AUTHORS: KULWICKI, P.V.

REPORT DATE: 76/03  
PAGINATION: 31P  
REPORT SERIES NUMBER: AMRL-TR-75-124

ABSTRACT: THE EFFECTS OF AIRCRAFT ANGLE OF ATTACK AND FLIGHT  
PATH ACCELERATION DURING HIGH GZ FIGHTER MANEUVERING ON THE POSITION OF THE  
RESULTANT GZ RELATIVE TO THE PILOT ARE EXAMINED BY MEANS OF A COMPUTER  
SIMULATED DOGFIGHT ENGAGEMENT. IT IS DEMONSTRATED THAT A TRANSIENT SHIFTING  
IN POSITION OF THE RESULTANT GZ RELATIVE TO AN AIRCRAFT VERTICAL REFERENCE IS  
CORRELATED WITH VARIATIONS IN FLIGHT PATH ACCELERATION, WHICH OCCUR DUE TO  
PILOT ACTUATION OF CONTROLS WITH ATTENDANT CHANGES IN FLIGHT PATH  
CHARACTERISTICS. ALTHOUGH TIME INTERVALS DURING HIGH GZ TURNS ARE NOTED  
WHEREIN HIGH VALUES FOR AIRCRAFT ANGLE OF ATTACK COINCIDE WITH HIGH VALUES FOR  
THE POSITION OF RESULTANT G FORWARD OF AIRCRAFT VERTICAL, THESE CASES  
GENERALLY OCCUR AT SUBSONIC (M EQUAL TO OR LESS THAN 0.7) AIRSPEEDS AND FOR  
THE 'BEST' CASE FOR WHICH THE MAXIMUM POWER THROTTLE SETTING IS ELECTED. FOR  
HIGH GZ TURNS AT TRANSONIC AND SUPERSONIC SPEEDS, THE ASSOCIATED ANGLE OF  
ATTACK IS SUBSTANTIALLY REDUCED, AS IS THE MAXIMUM INCLINATION OF RESULTANT GZ  
FORWARD OF VERTICAL FOR THE BEST CASE OF MAXIMUM POWER SETTING. APPLICATION  
OF SPEED BRAKES OR SELECTION OF AN INTERMEDIATE POWER SETTING HAS THE EFFECT  
OF SHIFTING THE GZ-VECTOR AFT. IT IS CONCLUDED THAT THE ARBITRARY ADDITION OF  
A LARGE ANGLE EQUAL TO THE AIRCRAFT ANGLE OF ATTACK TO THE EJECTION SEAT BACK  
ANGLE TO PROVIDE ADDED PILOT PROTECTION AGAINST HIGH GZ FORCES IS NOT  
WARRANTED.

ACCESSION NUMBER: 47622  
SOURCE NAME: MCDONNELL AIRCRAFT COMPANY, MCDONNELL DOUGLAS  
CORPORATION, ST. LOUIS, MO

TITLE: AFTI-15 PREDESIGN AND PRELIMINARY DEVELOPMENT OF DFCS  
AND HAC, VOLUME III TECHNICAL PROPOSAL

REPORT DATE: 77/04/14  
PAGINATION: 1 VOLUME  
REPORT SERIES NUMBER: MDC A4697

**ABSTRACT:** TODAY'S FRONT LINE FIGHTER AIRCRAFT, THE F-15, HAS MORE MANEUVERABILITY THAN HAS BEEN DESIGNED INTO PREVIOUS AIRCRAFT. CURRENT DESIGN TRENDS CONTINUE TO EMPHASIZE THE COMPLEMENTARY BENEFITS OF HIGH MANEUVERABILITY COUPLED WITH ADVANCES IN AVIONICS AND ARMAMENT. HIGH MANEUVERING LOAD FACTORS (NO LOSS OF AIRSPEED OR ALTITUDE) CAN NOW BE SUSTAINED IN A SIGNIFICANT PORTION OF THE TOTAL FLIGHT ENVELOPE. THIS NEW CAPABILITY IS A CONSEQUENCE OF THE EMERGENCE OF MORE POWERFUL ENGINES, LIGHTWEIGHT MATERIALS AND NEW FABRICATION TECHNIQUES, AND EFFICIENT HIGH LIFT SYSTEMS AND WING DESIGN. FROM THE PILOT'S PERSPECTIVE, ESPECIALLY WITH REGARD TO COMBAT MANEUVERING, ADDED MANEUVER AGILITY CAN INCREASE HIS TACTICAL ADVANTAGE AND ENHANCE HIS SURVIVABILITY, BUT ONLY IF HE IS PHYSIOLOGICALLY ABLE TO UTILIZE HIS AIRCRAFT CAPABILITIES.

**ACCESSION NUMBER:** 47623  
**SOURCE NAME:** MCDONNELL AIRCRAFT COMPANY, ST LOUIS, MO  
**TITLE:** AFTI-15 PREDESIGN AND PRELIMINARY DEVELOPMENT OF DFCS AND HAC, SUPPLEMENT TO VOLUME III HAC  
**REPORT DATE:** 77/04/18  
**PAGINATION:** 68P  
**REPORT SERIES NUMBER:** MDC IR0046

**ABSTRACT:** THIS DOCUMENT HAS BEEN PREPARED AS SUPPLEMENTARY DATA FOR THE MCAIR AFTI-15 PREDESIGN AND PRELIMINARY DEVELOPMENT OF DFCS AND HAC, VOLUME III - HAC TECHNICAL PROPOSAL, SUBMITTED TO USAF FLIGHT DYNAMICS LABORATORY IN RESPONSE TO RFP F33615-77-R-3064 ON 14 MARCH 1977. DOCUMENTS MCAIR UNDERSTANDING OF REQUIREMENTS.

**ACCESSION NUMBER:** NA  
**SOURCE NAME:** COMBINED STRESS BRANCH, ARMSTRONG LABORATORY, WRIGHT-PATTERSON AFB, OH  
**TITLE:** POTENTIAL HUMAN FACTORS' EFFECTS DUE TO HIGH ALPHA FLIGHT  
**PERSONAL AUTHORS:** REPPERGER, D.W.  
**REPORT DATE:** 92/4  
**PAGINATION:** 1P  
**SUPPLEMENTARY NOTE:** ABSTRACT FROM SAE AEROSPACE ATLANTIC PROCEEDINGS

**ABSTRACT:** THE ROLE OF THE ARMSTRONG LABORATORY AT WRIGHT-PATTERSON AIR FORCE BASE IS TO INVESTIGATE THE HUMAN FACTORS' EFFECTS ON PILOTS DURING THESE UNUSUAL FLIGHT SCENARIOS VIA CENTRIFUGE SIMULATION OF PILOTS AND EQUIPMENT. RECENTLY X-29 DATA HAVE BEEN DELIVERED TO THE ARMSTRONG LABORATORY DURING HIGH ALPHA FLIGHT. ANALYSIS OF THESE DATA SHOW EXACTLY WHAT TYPES OF COMPLEX ACCELERATIONS AND ATTITUDE ROTATIONS ACT ON A PILOT DURING THESE UNTOWARD FLIGHT SCENARIOS. THIS PAPER REPORTS THE ANALYSIS OF THESE X-29 DATA AS WELL AS HOW EQUIVALENT MOTION FIELDS CAN BE SIMULATED ON A CENTRIFUGE SIMULATOR TO INVESTIGATE THESE POTENTIAL HUMAN FACTORS' EFFECTS ON PILOTS. SINCE THESE MOTION FIELDS ARE WELL SPECIFIED, TOPICS SUCH AS POSSIBLE

DISORIENTATION, THE EFFECT ON TRAINING, ADJUSTMENT TO THE LOSS OF CONTROL DURING HIGH ALPHA FLIGHT, AND OTHER EFFECTS ON PILOTS DUE TO THIS UNUSUAL FLIGHT REGIME ARE DESCRIBED.

ACCESSION NUMBER: 89-455  
SOURCE NAME: POPULAR SCIENCE  
  
TITLE: X-31: HOW THEY'RE INVENTING A RADICAL NEW WAY TO FLY  
  
PERSONAL AUTHORS: SCHEFTER, J.  
  
REPORT DATE: 89/02  
PAGINATION: 7  
SUPPLEMENTARY NOTE: MAGAZINE ARTICLE  
DIST/AVAIL STATEMENT: FROM SOURCE  
  
ABSTRACT: POPULAR PRESS ARTICLE ON THE CAPABILITIES OF NEW, SUPERMANEUVERABILITY AIRCRAFT CAPABLE OF MANEUVERING IN THE POST-STALL REGIME.

ACCESSION NUMBER: NA  
SOURCE NAME: ARMSTRONG LABORATORY, AL/XPT, BROOKS AFB, TX  
  
TITLE: GROUND SIMULATION OF HIGH AGILITY FLIGHT  
  
PERSONAL AUTHORS: TEDOR, J.B.  
  
REPORT DATE: 92/4  
PAGINATION: 4P  
SUPPLEMENTARY NOTE: ARTICLE FROM SAE AEROSPACE ATLANTIC PROCEEDINGS  
  
ABSTRACT: TO GENERATE A REALISTIC PERCEPTION OF THE HIGH AGILITY FLIGHT ENVIRONMENT, MAN-IN-THE-LOOP SIMULATION WILL REQUIRE A VERY CAPABLE LARGE RADIUS CENTRIFUGE COMBINED WITH THE HIGH FIDELITY CREWSTATION, BEYOND-THE-COCKPIT VISUAL DISPLAY, AND CLOSED-LOOP CONTROL FEATURES OF A FIXED-BASE FLIGHT SIMULATOR. ARMSTRONG LABORATORY OF U.S. AIR FORCE SYSTEMS COMMAND IS DEVELOPING A FACILITY CONCEPT FOR GROUND SIMULATION OF HIGH AGILITY FLIGHT, THE COMBINED ACCELERATION FLIGHT SIMULATOR (CAFS). THE CAFS CONCEPT IS A TRACK-CENTRIFUGE WITH AN ELECTROMAGNETIC PROPULSION SYSTEM AND CREWSTATION WHICH CAN ROTATE ON ANY AXIS. CAFS WILL BE A VERSATILE NATIONAL RESEARCH AND TEST ASSET WHICH WILL ENABLE DEVELOPMENT OF A NEW CLASS OF SUPERAGILE FLIGHT VEHICLES.

ACCESSION NUMBER: 8198  
AD: B  
AD NUMBER: 036611  
  
SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA  
  
TITLE: FEASIBILITY OF RETROFITTING CURRENT NAVY AIRCRAFT COCKPITS TO ACHIEVE IMPROVED CREWMEMBER GZ TOLERANCE  
  
PERSONAL AUTHORS: ZENOBI, T.J.

REPORT DATE: 79/03/27  
PAGINATION: 15P  
REPORT SERIES NUMBER: NADC-79017-60

ABSTRACT: EXTENSIVE COCKPIT MODIFICATION IN CURRENT HIGH PERFORMANCE NAVY AIRCRAFT IS REQUIRED TO PROTECT CREWMEMBERS FROM SUSTAINED ACCELERATION LOADS OF APPROXIMATELY 8 TO 10 GZ. CURRENTLY, MOST CREWMEMBERS CANNOT PERFORM ADEQUATELY AT LEVELS OF ABOUT 4 GZ AND GREATER. IMPROVEMENTS IN THE DESIGN OF ANTI-G SUITS/VALVES MAY INCREASE GZ TOLERANCE BY 1 OR 2 GZ AND REQUIRE NOMINAL MODIFICATION TO THE COCKPIT. INCORPORATION OF A SUPINATING SEAT REQUIRES INSTRUMENT PANEL, FLIGHT CONTROLS AND EJECTION SEAT MODIFICATION. BEFORE AN INTENSIVE EFFORT IS UNDERTAKEN TO ACHIEVE CREWMEMBER PROTECTION AGAINST SUSTAINED GZ EFFECTS, THE NAVY MUST FIRST BE SURE THAT THE BENEFITS WILL BE WORTH THE LARGE SUMS OF FUNDS WHICH WILL BE SPENT. A RE-EVALUATION OF THE NEED FOR A SUSTAINED G PROTECTION RETROFIT EFFORT IS RECOMMENDED.

## HIGH ACCELERATION COCKPIT RESEARCH

### EJECTION AND ESCAPE

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The Boeing work documented in Accession Numbers 48738, 48747, 45919, 46380 (below) appears to deal with a radically reclined seat design suitable for ejection at up to 1600Q (1600 lb/sq ft). This work should be reviewed prior to any final decision on the design of a research seat so that, to the extent possible, the research seat poses no design features that are not reconcilable with the ejection requirement.

The North American Aircraft Division report (46587) should also be examined even though it appears to be much less comprehensive than the Boeing study. A review of the prone escape system (PRESS) concept indicates that on a (theoretical) hydrostatic basis it does not offer any remarkable advance in G protection and probably does not warrant consideration.

The canopy module escape system (40350) is not an idea that has received a high degree of acceptance in the ejection seat community and any consideration of that concept would have to be considered in the light of that community's past experience and future planning.

In any case, the ejection provisions of any future HAC seat design must take into account the considerable body of research that has been done in the CREST program in order to conserve as much of that effort as possible in designing a reclined seat.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 47625

SOURCE NAME: DOUGLAS AIRCRAFT COMPANY, MCDONNELL DOUGLAS CORPORATION, LONG BEACH, CA

TITLE: ACES-II HIGH TECHNOLOGY EJECTION SEAT

REPORT DATE: 75/07/02

PAGINATION: 17P

REPORT SERIES NUMBER: MDC J4493A

ABSTRACT: ACES-II, THE HIGH TECHNOLOGY EJECTION SEAT, IS A HIGH-PERFORMANCE ESCAPE SYSTEM DEVELOPED BY DOUGLAS AIRCRAFT COMPANY UNDER CONTRACT TO THE UNITED STATES AIR FORCE. THE INCREASED PERFORMANCE CAPABILITY GREATLY IMPROVES THE SURVIVABILITY OF AIRCREWS DURING ESCAPE FROM AIRCRAFT UNDER ADVERSE CONDITIONS THROUGHOUT THE FLIGHT ENVELOPE. THE EXPERIENCE GAINED BY DOUGLAS ENGINEERS IN OVER 25 YEARS OF ESCAPE SYSTEM DESIGN, DEVELOPMENT, AND MANUFACTURE HAS BEEN APPLIED TO MAKE ACES-II A RUGGED, LIGHTWEIGHT, EASY TO MAINTAIN EJECTION SEAT WITH ADVANCED-TECHNOLOGY SUBSYSTEMS. THE SUBSYSTEMS WERE DESIGNED, TESTED, AND QUALIFIED IN THE USAF/DOUGLAS ACES-I RESEARCH AND DEVELOPMENT PROGRAM, AND ARE INTEGRAL IN THE

ALL-NEW SEAT STRUCTURE OF ACES-II. QUALIFICATION TESTS OF THE ACES-II SYSTEM WERE COMPLETED IN JUNE 1973. THE "HIGH TECHNOLOGY" CHARACTERISTICS OF THE SEAT AND ITS SUBSYSTEMS ARE ILLUSTRATED.

ACCESSION NUMBER: 48738  
SOURCE NAME: BOEING MILITARY AIRPLANE CO., SEATTLE, WA  
TITLE: ASSESSMENT OF ADVANCED EJECTION SEAT CONCEPTS; A  
PROGRESS REPORT  
PERSONAL AUTHORS: BRISTER, J.G., BULL, J.O., YURCZYK, R.F., PETERS, J.M.  
REPORT DATE: 81/12/06  
PAGINATION: 6P  
SUPPLEMENTARY NOTE: PRESENTED AT 19TH ANNUAL SYMPOSIUM, SAFE ASSOCIATION,  
LAS VEGAS, NV, 6-10 DECEMBER 1981  
DIST/AVAIL STATEMENT: PUB. IN PROCEEDINGS, SAFE ASSOCIATION, PP 268-273,  
1981

ABSTRACT: A HIGH Q RECLINED EJECTION SEAT IS UNDER DEVELOPMENT TO REDUCE WINDBLAST, MINIMIZE THE FORCES ON THE CREWMEMBER, AND TO PREVENT LIMB FLAIL DURING ESCAPE, WHEN PRESSURES OF UP TO 1600 PSF CAN BE ENCOUNTERED. THE RECLINED FEATURE OF THE SEAT PERMITS ENHANCED PILOT PERFORMANCE UNDER HIGH ACCELERATION, AND ALSO IS MORE COMFORTABLE TO A LOW PROFILE COCKPIT DESIGN.

ACCESSION NUMBER: 48747  
SOURCE NAME: BOEING MILITARY AIRPLANE CO., SEATTLE, WA  
TITLE: PERFORMANCE ASSESSMENT OF A RECLINED EJECTION SEAT  
PERSONAL AUTHORS: BRISTER, J.G., . AND YURCZYK, R.F.  
REPORT DATE: 83/07  
PAGINATION: 4P  
DIST/AVAIL STATEMENT: PUB. IN SAFE JOURNAL 13:21-24 SUMMER 1983

ABSTRACT: NEW CONCEPTS ARE CURRENTLY BEING DEVELOPED REGARDING THE DESIGN OF EJECTION SEATS WITH THE OBJECTIVE TO MEET THE REQUIREMENTS OF ADVANCED TECHNOLOGY COMBAT AIRCRAFT. THE OBJECTIVE OF THIS PROGRAM IS RELATED TO THE DEVELOPMENT OF AN ESCAPE SYSTEM WHICH CAN BE INTEGRATED WITH A LOW PROFILE COCKPIT. A 1/2 SCALE MODEL OF THE RECLINED SEAT WAS FABRICATED AND TESTED IN A WIND TUNNEL. IT WAS FOUND THAT THE RECLINED EJECTION SEAT INCORPORATING A REPOSITIONING CATAPULT AND EJECTION ROCKET WITH THRUST VECTOR CONTROL IS A FEASIBLE CONCEPT FOR ESCAPE THROUGHOUT THE FLIGHT ENVELOPE OF A HIGH PERFORMANCE AIRCRAFT.

ACCESSION NUMBER: 45919  
AD: B  
AD NUMBER: 063423  
SOURCE NAME: BOEING MILITARY AIRPLANE CO, SEATTLE, WA

**TITLE:** RECLINED EJECTION SEAT DEVELOPMENT

**PERSONAL AUTHORS:** BRISTER, J.G., AND YURCZYK, R.F.

**REPORT DATE:** 82/01  
**PAGINATION:** 289P  
**MONITOR ACRONYM:** AFWAL  
**MONITOR SERIES:** AFWAL-TR-81-3164  
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**ACCESSION NUMBER:** 7664  
**AD:** B  
**AD NUMBER:** 060441  
**SOURCE NAME:** AIR FORCE WRIGHT AERONAUTICAL LABORATORY, WRIGHT-  
PATTERSON AFB, OHIO

**TITLE:** RECLINED EJECTION SEAT DEVELOPMENT WIND TUNNEL TEST  
REPORT

**PERSONAL AUTHORS:** BRISTER, J.G., AND YURCZYK, R.F.

**REPORT DATE:** 81/08  
**PAGINATION:** 104P  
**MONITOR ACRONYM:** AFWAL  
**MONITOR SERIES:** AFWAL-TR-81-3100  
**DIST/AVAIL STATEMENT:** DISTRIBUTION LIMITED TO US GOV'T AGENCIES ONLY: TEST  
AND EVALUATION: AUG 81. OTHER REQUESTS FOR THIS  
DOCUMENT MUST BE REFERRED TO COMMANDER, WRIGHT LAB,  
WRIGHT-PATTERSON AFB, OH

**ABSTRACT:** WIND TUNNEL TESTS WERE CONDUCTED TO EVALUATE THE  
AERODYNAMIC CHARACTERISTICS OF A RECLINED EJECTION SEAT. THESE TESTS ARE PART  
OF A DEVELOPMENT PROGRAM "RECLINED EJECTION SEAT DEVELOPMENT," CONTRACT  
F33615-80-C-3404. THE OBJECTIVE OF THIS PROGRAM IS TO DEVELOP A RECLINED  
EJECTION SEAT DESIGN WHICH IS INCORPORATED INTO A LOW PROFILE COCKPIT AND  
WHICH WILL PROVIDE SAFE ESCAPE DURING EMERGENCY CONDITIONS ENCOUNTERED  
THROUGHOUT THE PERFORMANCE ENVELOPE OF AN AIRCRAFT WITH SPEED CAPABILITY TO  
687 KEAS. PRELIMINARY PHASES OF THIS PROGRAM HAVE RESULTED IN SELECTION AND  
DEFINITION OF TWO EJECTION CONCEPTS, ONE EMPHASIZING A REPOSITIONING CATAPULT  
WITH A A RAIL-CATAPULT SYSTEM. BOTH CONCEPTS EMPLOY AERO-DYNAMIC  
STABILIZATION DEVICES MOUNTED NEAR THE SEAT HEADREST. A ONE-HALF SCALE MODEL  
OF THE SEAT/CREWMEMBER WAS FABRICATED AND TESTED IN THE AEDC PWT 16T TRANSONIC  
TUNNEL. AERODYNAMIC DATA DERIVED FROM THESE TESTS WILL BE USED IN SIX  
DEGREE-OF-FREEDOM COMPUTER SIMULATIONS FOR PERFORMANCE ASSESSMENTS OF THE  
RECLINED EJECTION SEAT CONCEPT.

**ACCESSION NUMBER:** 46380  
**SOURCE NAME:** BOEING MILITARY AIRPLANE COMPANY, P.O. BOX 3707,  
SEATTLE, WA



**TITLE:** ADVANCED EJECTION SEAT FOR HIGH DYNAMIC PRESSURE  
ESCAPE

**PERSONAL AUTHORS:** BULL, J.O., AND YURCZYK, R.F.

**REPORT DATE:** 81/11

**PAGINATION:** 293P

**MONITOR ACRONYM:** AFWAL

**MONITOR SERIES:** AFWAL-TR-81-3131

**DIST/AVAIL STATEMENT:** DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES  
ONLY; TEST AND EVALUATION, AUGUST 1981.

**ABSTRACT:** TECHNOLOGY IMPROVEMENTS IN ADVANCED COMBAT AIRCRAFT HAVE EXPANDED THE OPERATIONAL MANEUVERING ENVELOPE BEYOND THE CAPABILITY OF CURRENT EJECTION SEATS. THEREFORE, DEVELOPMENT OF A STABLE SEAT WHICH INCORPORATES ADEQUATE LIMB RESTRAINT PROTECTION FROM WINDBLAST AND REDUCED ACCELERATION IS REQUIRED TO REDUCE THE RISK OF MAJOR OR FATAL INJURY DURING EJECTION. THE OBJECTIVE OF THIS PROGRAM WAS TO EVALUATE CONCEPTS AND DEVELOP A SYSTEM DESIGN WHICH, WHEN INCORPORATED IN A MODERN CONVENTIONAL EJECTION SEAT, WILL REDUCE WINDBLAST, MINIMIZE LOADS ON THE CREWMEMBER AND PREVENT LIMB FLAIL, THUS PROVIDING SAFE ESCAPE DURING EMERGENCY CONDITIONS AT SPEEDS TO 687 KEAS ( $Q = 1600$  PSF). THE PROGRAM WAS DIVIDED INTO SEVEN TASKS INCLUDING: (1) IDENTIFICATION AND EVALUATION OF NEW CONCEPTS, (2) WIND TUNNEL MODEL DESIGN AND FABRICATION, (3) WIND TUNNEL TESTS, (4) PRELIMINARY DESIGN, (5) PERFORMANCE ASSESSMENT, (6) DESIGN REFINEMENT, AND (7) MOCKUP DESIGN AND FABRICATION. THE PROGRAM RESULTED IN A DESIGN WHICH INCORPORATED AN INFLATABLE AFT BODY STABILIZER, ROCKET THRUST VECTOR CONTROL, AUXILIARY ROCKETS, AND A PASSIVE WINDBLAST SCREEN AND LIMB RESTRAINT SYSTEM INTO A CONVENTIONAL EJECTION SEAT. SUCCESSFUL ESCAPE COULD BE ACHIEVED THROUGHOUT THE PERFORMANCE ENVELOPE TO SPEEDS OF 687 KEAS AND ALTITUDES TO 50,000 FEET.

**ACCESSION NUMBER:** 46587

**SOURCE NAME:** NORTH AMERICAN AIRCRAFT DIVISION, LOS ANGELES, CA

**TITLE:** INVESTIGATION OF AIRCREW PROTECTION DURING EMERGENCY  
ESCAPE AT DYNAMIC PRESSURES UP TO 1600 Q.

**PERSONAL AUTHORS:** CUMMINGS, R.J.

**REPORT DATE:** 82/05

**PAGINATION:** 75P

**REPORT SERIES NUMBER:** NA-80-871

**MONITOR ACRONYM:** AFAMRL

**MONITOR SERIES:** AFAMRL-TR-81-71

**ABSTRACT:** A PERSPECTIVE IS DEVELOPED ON REQUIREMENTS FOR APPLIED BIOMECHANICAL RESEARCH NECESSARY TO SUPPORT DEVELOPMENT OF NEW ADVANCED ESCAPE CAPABILITY FOR NEGATIVE STATIC STABILITY MARGIN AIRCRAFT. PROCESSES WHICH GOVERN POTENTIALLY INJURIOUS ENERGY TRANSFERS TO AND FROM THE EJECTEE ARE ENUMERATED. FOUR ESCAPE DESIGN APPROACHES ARE EVALUATED IN TERMS OF ENERGY TRANSFERS, PROTECTION STRATEGIES, AND RESEARCH REQUIREMENTS, INCLUDING (1) ADVANCED OPEN UPRIGHT SEAT, (2) RECLINED OPEN, (3) PARTIALLY ENCAPSULATED, AND (4) ENCAPSULATED.

**ACCESSION NUMBER:** NA  
**SOURCE NAME:** AIR FORCE INSTITUTE OF TECHNOLOGY  
**TITLE:** PRONE ESCAPE SYSTEM (PRESS) DESIGN STUDY  
**PERSONAL AUTHORS:** DISSELKOEN, A.D., GARGIULO, R.F., HAYWOOD, J.E.,  
 HEISE, K.H., HOLCOMB, D.H., MILLER, G.R., NICHOLSON,  
 J.S., AND OLINGER J.J.  
**REPORT DATE:** 87/12  
**PAGINATION:** 200 APPROX.  
**REPORT SERIES NUMBER:** AFIT/GSE/AA/87D-2  
**SUPPLEMENTARY NOTE:** THESIS-MS IN SYSTEMS ENGINEERING  
**DIST/AVAIL STATEMENT:** DISTRIBUTION LIMITED TO US GOVERNMENT AGENCIES AND  
 THEIR CONTRACTORS; CRITICAL TECHNOLOGY. OTHER  
 REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO THE  
 ESCAPE AND IMPACT PROTECTION BRANCH, AL/CFBE, WRIGHT-  
 PATTERSON AFB, OH 45433-6573

**ABSTRACT:** FUTURE FIGHTER AIRCRAFT WILL SUSTAIN MORE G-FORCES  
 THAN A PILOT CAN TOLERATE. THE PRONE (FORWARD LEANING) FLYING POSITION OFFERS  
 ENHANCED PILOT G-TOLERANCE AND IS BEING CONSIDERED IN FUTURE FIGHTER DESIGNS.  
 THIS THESIS DESIGN TEAM INVESTIGATED EJECTION FROM A PRONE POSITION. FIRST, A  
 FEASIBLE PRONE FIGHTER SEAT WAS DESIGNED. IT WAS THEN DIMENSIONED TO FIT THE  
 5TH TO 95TH PERCENTILE PILOT WITH A HUMAN FACTORS ANALYSIS, AND REFINED USING  
 THE ROMULUS CAD PROGRAM. A COMPLETE AERODYNAMIC ANALYSIS, USING THE MARK IV  
 SUPERSONIC-HYPERSONIC ARBITRARY BODY COMPUTER PROGRAM, SHOWED STATIC STABILITY  
 IN THE WINDSTREAM. A CATAPULT/SUSTAINER ROCKET PROPULSION AND CONTROL SYSTEM  
 WAS DESIGNED TO POSITION THE SEAT AT ITS AERODYNAMIC STABILITY ANGLE OF  
 ATTACK. FINALLY, THE EASIEST SIMULATION PACKAGE WAS USED TO SIMULATE PRESS  
 EJECTIONS THROUGHOUT THE EJECTION ENVELOPE UP TO AN ALTITUDE OF 70,000 FEET, A  
 DYNAMIC PRESSURE OF 2000 PSF AND AN AIRSPEED OF MACH 3. PRESS'S ADVANTAGES  
 OVER CONVENTIONAL EJECTION SYSTEMS ARE AN EXPANDED EJECTION ENVELOPE,  
 INCREASED CATAPULT G-FORCE PROTECTION, WINDBLAST PROTECTION, AND STABILITY IN  
 THE WINDSTREAM. (AUTHORS)

**ACCESSION NUMBER:** 48742  
**SOURCE NAME:** BRITISH AEROSPACE, KINGSTON-UPON-THAMES, SURREY,  
 ENGLAND  
**TITLE:** THE DESIGN OF FUTURE COCKPITS FOR HIGH PERFORMANCE  
 FIGHTER AIRCRAFT  
**PERSONAL AUTHORS:** ROE, G.  
**REPORT DATE:** 78/04  
**PAGINATION:** 8P  
**DIST/AVAIL STATEMENT:** PUB. IN AERONAUTICAL JOURNAL 82:159-166 APRIL 1978

**ABSTRACT:** MEANS OF INCREASING A PILOT'S G-TOLERANCE THROUGH  
 INCREASING THE RECLINE ANGLE OF THE SEAT ARE DISCUSSED, AND THE CORRESPONDING  
 MODIFICATIONS REQUIRED IN COCKPIT DISPLAYS AND EJECTOR DESIGN ARE CONSIDERED.  
 IN PARTICULAR, AN ARTICULATED SEAT PROVIDING THE ADDITIONAL RECLINE ANGLE TO  
 GIVE A TOLERANCE INCREASE OF ABOUT 2 GZ MAGNITUDE OVER PRESENT LEVELS IS

PROPOSED. OPTIMUM LOCATIONS FOR FLIGHT, SENSOR AND SYSTEMS DATA DISPLAYS ARE DETERMINED ON THE BASIS OF INFORMATION REQUIREMENTS FOR THE PILOT DURING TAKEOFF, CLIMB, CRUISE AND OTHER MANEUVERS. A HEAD-UP DISPLAY FOR FLIGHT INFORMATION AND A HEAD-LEVEL DISPLAY FOR SENSOR DATA ARE SUGGESTED.

ACCESSION NUMBER: 40350  
SOURCE NAME: CREW ESCAPE AND SUBSYSTEMS BRANCH, WL/FIER,  
WRIGHT-PATTERSON AFB, OH

TITLE: A CANOPY MODULE ESCAPE SYSTEM FOR FUTURE TACTICAL  
AIRCRAFT

PERSONAL AUTHORS: SCHULTZ, E.R.

REPORT DATE: 83/11/05  
PAGINATION: 6P  
SUPPLEMENTARY NOTE: SAFE ASSOCIATION PROCEEDINGS, 5-8 NOV 83, SAN ANTONIO,  
TX  
DIST/AVAIL STATEMENT: PUB. IN 1983 SAFE ASSOCIATION PROCEEDINGS, (ACCESS  
NO. 10742), P 171-176

ABSTRACT: A REVIEW OF CREW ESCAPE STATISTICS SHOWS THAT THE HIGH DYNAMIC PRESSURE AND LOW ALTITUDE/ADVERSE ATTITUDE FLIGHT CONDITIONS ARE THE MOST HAZARDOUS AREAS OF THE FLIGHT ENVELOPE FOR CREW ESCAPE. ATTEMPTS TO IMPROVE SYSTEM PERFORMANCE IN ONE OF THESE FLIGHT REGIMES HAVE OFTEN RESULTED IN DEGRADATION IN THE OTHER AREA. A NEED EXISTS FOR A SINGLE CREW ESCAPE SYSTEM WHICH PROVIDES WINDBLAST AND ACCELERATION PROTECTION AT SPEEDS IN EXCESS OF 700 KNOTS YET REACTS FAST ENOUGH TO SATISFY THE UNIQUE LOW ALTITUDE/ADVERSE ATTITUDE REQUIREMENTS. THE RECLINED EJECTION SEAT COUPLED WITH THE SINGLE PIECE TRANSPARENCY PROVIDES AN EXCELLENT OPPORTUNITY TO EXPLOIT THE CANOPY ESCAPE SYSTEM CONCEPT FOR ADVANCED TACTICAL AIRCRAFT. THIS CONCEPT, HOWEVER, MAY NOT REACT FAST ENOUGH FOR THE LOW ALTITUDE/ADVERSE ATTITUDE SITUATION. CONSEQUENTLY, A HYBRID SYSTEM IS PROPOSED COMBINING THE ADVANTAGES OF THE OPEN EJECTION SEAT WITH THOSE OF THE CANOPY ESCAPE SYSTEM. IT IS CONCLUDED THAT NEW TECHNOLOGIES UNDER DEVELOPMENT IN THE USAF IN DIGITAL ADAPTIVE CONTROL, SELECTABLE THRUST ROCKETS AND ATTITUDE CONTROL COULD PROVIDE THE BASIS FOR DEVELOPING SUCH A SYSTEM. IT IS ALSO CONCLUDED THAT INTEGRATION OF THE ESCAPE SYSTEM INTO THE AIRFRAME SHOULD BE ACHIEVED IN THE CONCEPTUAL DESIGN OF THE AIRCRAFT IN ORDER TO INFLUENCE THE DESIGN OF THE CREW STATION AND AERODYNAMIC STABILIZERS.

ACCESSION NUMBER: NA  
AD NUMBER: AD-A081 055  
SOURCE NAME: GRUMMAN AEROSPACE CORPORATION, SPONSORED BY THE AIR  
FORCE FLIGHT DYNAMICS LABORATORY, WRIGHT PATTERSON  
AFB, OH

TITLE: INVESTIGATION OF MEDIUM-SIZED LOW PROFILE COCKPITS AND  
CREW ESCAPE SYSTEM INTEGRATION

PERSONAL AUTHORS: TAUBY, W.C.  
REPORT DATE: 79/07  
PAGINATION: 237P

REPORT SERIES NUMBER: AFFDL-TR-79-3104  
SUPPLEMENTARY NOTE: TECHNICAL REPORT

ABSTRACT: ASSESSED ARE THE POTENTIAL BENEFITS DERIVED FROM THE APPLICATION TO ADVANCED FIGHTER AIRCRAFT CONFIGURATIONS AND THE INTEGRATION OF AN EFFECTIVE CREW ESCAPE CAPABILITY. ALTERNATE APPROACHES AND ESCAPE CONCEPTS WERE IDENTIFIED AND SUBJECTED TO ANALYSIS AND TRADEOFF TO PERMIT THE RECOMMENDATION OF PREFERRED CONCEPTS. THE COMPUTER SIMULATION OF ESCAPE SYSTEM AERODYNAMIC PERFORMANCE FACILITATED THE EVALUATION LEADING TO THE SELECTION OF THE SUPINE CONCEPT AS THAT PREFERRED FOR FURTHER DEVELOPMENT AS A PRELIMINARY DESIGN. (AUTHOR)

ACCESSION NUMBER: 7880  
AD: A  
AD NUMBER: 145439  
SOURCE NAME: AF AEROSPACE MEDICAL RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH

TITLE: THE HIGH ACCELERATION COCKPIT (HAC): A TECHNOLOGY BASE OVERVIEW - 1983

PERSONAL AUTHORS: VAN PATTEN, R.E., JENNINGS, T.J., AND MAXWELL, M.

REPORT DATE: 83/06  
PAGINATION: 5P  
REPORT SERIES NUMBER: AFAMRL-TR-84-075  
SUPPLEMENTARY NOTE: SAFE ASSOCIATION MEETING, 5-8 NOV 83, SAN ANTONIO, TX  
DIST/AVAIL STATEMENT: PUB. IN 1983 SAFE ASSOCIATION PROCEEDINGS (ACCESS NO. 10742), P 43-47; ALSO PUB. IN SAFE JOURNAL 14(2):16-21 SUMMER QUARTER 1984

ABSTRACT: REVIEW OF HAC TECHNOLOGY BASED UPON OVER 50 PUBLISHED PAPERS PRIOR TO THE DATE OF PUBLICATION OF THIS PAPER. ADDRESSES PRACTICAL CONCERNS REQUIRED TO MAKE A HAC COCKPIT OPERATIONALLY FEASIBLE: ERGONOMICS, VISION, EJECTION AND ESCAPE, MOBILITY, CONTROLS AND DISPLAYS.

# HIGH ACCELERATION COCKPIT RESEARCH

## ERGONOMICS HUMAN FACTORS/HUMAN ENGINEERING CONTROLLERS ANTHROPOMETRY

### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

At the commencement of a program of research on HAC, a copy of the report titled, "Paths of movement for selected body segments during typical pilot tasks" by Ayoub, et alia, should be used from the outset to structure the design of any seat used in the research to make certain that it is consistent to the extent possible with the physiological demands of high sustained +Gz.

Likewise, the report titled, "Selected design parameters for reclining seats based on engineering anthropometry" by Ayoub, et alia, should be obtained and utilized for the basic design of a research seat in order to make certain that this pre-existing body of research effort is exploited.

### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 48745  
AD: A  
AD NUMBER: 014811  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST. LOUIS, MO

TITLE: HIGH ACCELERATION COCKPIT CONTROLLER LOCATIONS.  
VOLUME II. TEST PLAN

PERSONAL AUTHORS: ASIALA, C.F., AND LOY, S.L.

REPORT DATE: 75/05  
PAGINATION: 80P  
REPORT SERIES NUMBER: MDC-A2960-VOL-2  
MONITOR ACRONYM: AFFDL  
MONITOR SERIES: AFFDL-TR-75-58-VOL-2

ABSTRACT: A HIGH ACCELERATION COCKPIT/CONTROLLER DESIGN AND INTEGRATION PROGRAM WAS CONDUCTED, USING A FULL SCALE DESIGN AID. ALTERNATE COCKPIT/CONTROLLER CONFIGURATIONS WERE DEVELOPED FOR COMPARISON USING THIS FULL SCALE DESIGN AID IN A FORMALLY STRUCTURED EVALUATION INCLUDING MISSION RELATED TASK ELEMENTS. CREW STATION AND CONTROLLER CHARACTERISTICS WERE THUS RELATED TO OPERATOR NEEDS IN A MISSION CONTEXT FOR ADVANCED FIGHTER CONCEPTS.

ACCESSION NUMBER: 4448  
AD: A  
AD NUMBER: 025773  
SOURCE NAME: TEXAS TECH UNIV LUBBOCK DEPT OF INDUSTRIAL  
ENGINEERING

**TITLE:** PATHS OF MOVEMENT FOR SELECTED BODY SEGMENTS DURING  
TYPICAL PILOT TASKS.

**PERSONAL AUTHORS:** AYOUB, M.M., DEIVANAYAGAM, S., AND KENNEDY, K.W.

**REPORT DATE:** 76/03  
**PAGINATION:** 396P  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-75-111

**ABSTRACT:** THE REPORT DESCRIBES THE GEOMETRY OF PATHS OF MOTION FOR BODY SEGMENTS WHEN THE HAND TRAVELS BETWEEN SELECTED CONTROL LOCATIONS WITHIN AN AIRCRAFT COCKPIT. THE CONTROLS SELECTED FOR THIS STUDY WERE THE STICK, THE THROTTLE, THE OVERHEAD, THE PANEL, THE SIDE-ARM AND THE HATCH. THE CONTROL LOCATIONS (START AND END POINTS OF THE HAND TRAVEL) WERE SELECTED TO REPRESENT BOTH CONVENTIONAL AND HIGH ACCELERATION TYPE AIRCRAFT COCKPITS. IN ADDITION, THREE DIFFERENT SEAT BACK REST ANGLES (13, 30 AND 65 DEGREES) WERE EMPLOYED TO REPRESENT THE CONVENTIONAL AND HIGH ACCELERATION SEAT CONFIGURATIONS. TO ADEQUATELY DESCRIBE THE MOVEMENTS OF ALL BODY SEGMENTS, THE FOLLOWING LANDMARKS ON THE BODY WERE STUDIED USING PHOTOGRAMMETRIC TECHNIQUES: NASION, CERVICALE, SUPRASTERNALE, ACROMION, SHOULDER JOINT CENTER, ELBOW JOINT CENTER, WRIST CENTER, GRIP CENTER AND GREATER TROCHANTER.

**ACCESSION NUMBER:** 4215  
**AD:** A  
**AD NUMBER:** 048458  
**SOURCE NAME:** TEXAS TECH UNIV LUBBOCK DEPT OF INDUSTRIAL  
ENGINEERING

**TITLE:** SELECTED DESIGN PARAMETERS FOR RECLINING SEATS BASED  
ON ENGINEERING ANTHROPOMETRY.

**PERSONAL AUTHORS:** AYOUB, M.M., DEIVANAYAGAM, S., AND KENNEDY, KENNETH W.

**REPORT DATE:** 77/09/00  
**PAGINATION:** 162P  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-77-44

**ABSTRACT:** THIS REPORT DISCUSSES SELECTED ENGINEERING ANTHROPOMETRIC DESIGN CRITERIA FOR RECLINING COCKPIT SEATS. THE RECLINING BACK-REST POSITIONS SELECTED WERE 13, 27, 51 AND 65 DEG. FROM THE VERTICAL LINE THROUGH THE SEAT REFERENCE POINT (SRP). TWO SEAT PAN ANGLES OF 10 AND 20 DEG WERE UTILIZED. THREE SEATING COMPONENTS WERE CONSIDERED IN THIS REPORT, THESE ARE: THE HEAD REST, ARM REST, AND FOOT REST. THE SPECIFIC ENGINEERING ANTHROPOMETRIC DESIGN PARAMETERS ADDRESSED WERE: THE HEAD REST HINGE POINT LOCATION, ARM REST LOCATION AND ORIENTATION IN SPACE AS THE SEAT RECLINES, LOCATION OF FOOT RESTS AND THE SYNCHRONIZATION OF ARM REST MOVEMENT WITH BACK REST INCLINATION.

ACCESSION NUMBER: 8110  
SOURCE NAME: US ARMY AEROMEDICAL RESEARCH LABORATORY, FORT RUCKER,  
AL  
  
TITLE: NECK MUSCLE STRESS INDUCED BY POSTURAL EFFECTS AND  
VIBRATION OF A SUPINE SEAT  
  
PERSONAL AUTHORS: JOHNSON, J.C., AND WELLS, J.H.  
  
REPORT DATE: 81/05  
PAGINATION: 2P  
SUPPLEMENTARY NOTE: AEROSPACE MEDICAL ASSOCIATION ANNUAL SCIENTIFIC  
MEETING, MAY 4-7 1981, CONVENTION CENTER, SAN ANTONIO,  
TX  
  
DIST/AVAIL STATEMENT: PREPRINTS OF 1981 ANNUAL SCIENTIFIC MEETING,  
AEROSPACE MEDICAL ASSOCIATION, 1981, P 209-210

ACCESSION NUMBER: 7533  
SOURCE NAME: ADVISORY GROUP FOR AEROSPACE RESEARCH AND  
DEVELOPMENT, FRANCE  
  
TITLE: ADDRESSING HUMAN FACTOR OPTIONS IN CONCEPTUAL DESIGN  
  
PERSONAL AUTHORS: KULWICKI, P.V.  
  
REPORT SERIES NUMBER: AGARD-CP-266  
SUPPLEMENTARY NOTE: IN AGARD CONFERENCE PROCEEDINGS NO. 266 OPERATIONAL  
ROLES, AIRCREW SYSTEMS AND HUMAN FACTORS IN FUTURE  
HIGH PERFORMANCE AIRCRAFT

ACCESSION NUMBER: 4819  
AD NUMBER: 757216  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST LOUIS, MO  
  
TITLE: THE HIGH G APPROACH.  
  
PERSONAL AUTHORS: KULWICKI, P.V., AND SINNETT, J.M.  
  
REPORT DATE: 73/02/20  
PAGINATION: 27P  
REPORT SERIES NUMBER: MDC-A2169  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-73-27

ABSTRACT: THE HIGH G APPROACH IS AN INNOVATIVE APPROACH TO  
COCKPIT DESIGN WHICH PROVIDES A UNIQUE MATCH OF PILOT CAPABILITIES AND  
AIRPLANE PERFORMANCE POTENTIAL. THE HIGH G APPROACH PROVIDES AN OPTION  
FOR THE PILOT TO THINK, COMMAND AND CONTROL HIS AIRCRAFT AT SUSTAINED LOAD  
FACTOR LEVELS WELL ABOVE 7 GZ. THE RESULT, IN THE CONTEXT OF EMERGING FIGHTER  
CAPABILITY, IS A DRAMATIC INCREASE IN COMBAT EFFECTIVENESS AND OPERATIONAL  
ADVANTAGE.

ACCESSION NUMBER: 48746  
AD: A  
AD NUMBER: 014810  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST. LOUIS, MO  
TITLE: HIGH ACCELERATION COCKPIT CONTROLLER LOCATIONS.  
VOLUME I. PROGRAM SUMMARY

PERSONAL AUTHORS: MATTES, R.E., AND ASIALA, C.F.

REPORT DATE: 75/05/00  
PAGINATION: 161P  
REPORT SERIES NUMBER: MDC-A2960-VOL-1  
MONITOR ACRONYM: AFFDL  
MONITOR SERIES: AFFDL-TR-75-58-VOL-1

ABSTRACT: A CONTROLLER-THROTTLE DESIGN INTEGRATION PROGRAM WAS CONDUCTED FOR AN ADVANCED FIGHTER CONCEPT WITH DIRECT LIFT, DIRECT SIDE FORCE, AND HIGH ACCELERATION MANEUVERING CAPABILITIES. SEVERAL CONTROLLER-THROTTLE CONFIGURATION DESIGN ALTERNATIVES WERE EVALUATED IN A HIGH ACCELERATION COCKPIT MOCK-UP BY USAF PILOTS IN A STATIC SIMULATION EVALUATION PHASE. COCKPIT AND CONTROLLER FUNCTIONAL CAPABILITIES WERE TAILORED TO SATISFY OPERATIONAL NEEDS FOR NORMAL FLIGHT AND COMBAT PHASES AND WERE EVALUATED WITHIN THE CONTEXT OF A FIGHTER MISSION. OBJECTIVE AND SUBJECTIVE DATA INCLUDING REACH AND VISION ENVELOPES, TASK PERFORMANCE TIMES, AND PILOT PREFERENCES FROM PAIRED COMPARISON AND INTERVIEW QUESTIONNAIRES WERE UTILIZED TO RANK THE CONFIGURATIONS EVALUATED. SEVERAL PRINCIPAL AREAS FOR FUTURE HIGH ACCELERATION COCKPIT DEVELOPMENT WERE DEFINED.

ACCESSION NUMBER: 48744  
AD: A  
AD NUMBER: 014812  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST. LOUIS, MO  
TITLE: HIGH ACCELERATION COCKPIT CONTROLLER LOCATIONS.  
VOLUME III. ONSITE PILOT EVALUATIONS

PERSONAL AUTHORS: MATTES, R.E., AND ASIALA, C.F.

REPORT DATE: 75/05/00  
PAGINATION: 43P  
REPORT SERIES NUMBER: MDC-A2960-VOL-3  
MONITOR ACRONYM: AFFDL  
MONITOR SERIES: AFFDL-TR-75-58-VOL-3

ABSTRACT: A HIGH ACCELERATION COCKPIT EVALUATION PROGRAM WAS CONDUCTED FOR AN ADVANCED FIGHTER CONCEPT. PROGRAM EFFORT INCLUDED EVALUATIONS WITHIN THE ADVANCED FIGHTER CONCEPT. PROGRAM EFFORT INCLUDED EVALUATIONS WITHIN THE CONTEXT OF A MISSION SCENARIO BY A TOTAL OF 40 OPERATIONAL PILOTS IN A STATIC DESIGN AID. VARIOUS SPECIFIC AREAS OF CONCEPT WERE EVALUATED AS WELL AS THE OVERALL NEED/UTILITY OF THE CREW STATION. RESULTING MEASURES ALLOWED IDENTIFICATION OF THOSE AREAS WHERE FUTURE R/D EFFORT SHOULD BE FOCUSED.



ACCESSION NUMBER: 48742  
SOURCE NAME: BRITISH AEROSPACE, KINGSTON-UPON-THAMES, SURREY,  
ENGLAND  
TITLE: THE DESIGN OF FUTURE COCKPITS FOR HIGH PERFORMANCE  
FIGHTER AIRCRAFT  
PERSONAL AUTHORS: ROE, G.  
REPORT DATE: 78/04/00  
PAGINATION: 8P  
DIST/AVAIL STATEMENT: PUB. IN AERONAUTICAL JOURNAL 82:159-166 APRIL 1978

ABSTRACT: MEANS OF INCREASING A PILOT'S G-TOLERANCE THROUGH  
INCREASING THE RECLINE ANGLE OF THE SEAT ARE DISCUSSED, AND THE CORRESPONDING  
MODIFICATIONS REQUIRED IN COCKPIT DISPLAYS AND EJECTOR DESIGN ARE  
CONSIDERED. IN PARTICULAR, AN ARTICULATED SEAT PROVIDING THE ADDITIONAL  
RECLINE ANGLE TO GIVE A TOLERANCE INCREASE OF ABOUT 2 GZ MAGNITUDE OVER  
PRESENT LEVELS IS PROPOSED. OPTIMUM LOCATIONS FOR FLIGHT, SENSOR AND SYSTEMS  
DATA DISPLAYS ARE DETERMINED ON THE BASIS OF INFORMATION REQUIREMENTS FOR THE  
PILOT DURING TAKEOFF, CLIMB, CRUISE AND OTHER MANEUVERS. A HEAD-UP DISPLAY FOR  
FLIGHT IS SUGGESTED.

ACCESSION NUMBER: 4612  
AD NUMBER: 913695  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST LOUIS, MO

TITLE: ADVANCED FIGHTER CONCEPTS INCORPORATING HIGH  
ACCELERATION COCKPITS. VOLUME V. CREW STATION  
CONCEPTS.

PERSONAL AUTHORS: SINNETT, J.M., AND EDGINGTON, L.N.

REPORT DATE: 73/07  
PAGINATION: 103P  
REPORT SERIES NUMBER: MDC-A1685-VOL-5  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-72-117  
SUPPLEMENTARY NOTE: SEE ALSO VOLUME 4, AD-913 694L.

ABSTRACT: A FEASIBILITY STUDY WAS CONDUCTED TO INVESTIGATE A  
HIGH ACCELERATION CREW STATION CONCEPT FOR FUTURE GENERATION FIGHTER AIRCRAFT.  
THE DEFINITION OF A FUNCTIONAL CREW STATION CONFIGURATION ENCOMPASSING  
THE CRITICAL FLIGHT PARAMETERS OF NORMAL AND HIGH G ENVIRONMENTS HAS BEEN  
ACCOMPLISHED.

ACCESSION NUMBER: 7880  
AD: A  
AD NUMBER: 145439  
SOURCE NAME: AF AEROSPACE MEDICAL RESEARCH LABORATORY,  
WRIGHT-PATTERSON AFB, OH

**TITLE:** THE HIGH ACCELERATION COCKPIT (HAC): A TECHNOLOGY  
BASE OVERVIEW - 1983

**PERSONAL AUTHORS:** VAN PATTEN, R.E., JENNINGS, T.J., AND MAXWELL, M.  
**REPORT DATE:** 83/06  
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**REPORT SERIES NUMBER:** AFAMRL-TR-84-075  
**SUPPLEMENTARY NOTE:** SAFE ASSOCIATION MEETING, 5-8 NOV 83, SAN ANTONIO, TX  
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10742), P 43-47; ALSO PUB. IN SAFE JOURNAL 14(2):16-21  
SUMMER QUARTER 1984

**ABSTRACT:** REVIEW OF OVER 50 PAPERS IN THE FIELD PUBLISHED PRIOR  
TO 1983. EMPHASIS IS ON THE NECESSITY FOR AN INTEGRATED DESIGN APPROACH  
TAKING INTO ACCOUNT REQUIREMENTS WITH RESPECT TO CONTROLS, DISPLAYS, VISION,  
MOBILITY, EJECTION, AND AERODYNAMICS.

**ACCESSION NUMBER:** 45811  
**SOURCE NAME:** ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY,  
WRIGHT-PATTERSON AFB, OH

**TITLE:** HUMAN FACTORS AND PERFORMANCE ISSUES IN THE DESIGN OF  
HIGH PERFORMANCE FIGHTER AIRCRAFT COCKPITS

**PERSONAL AUTHORS:** VAN PATTEN, R.E.

**REPORT DATE:** 85/10/11  
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**SUPPLEMENTARY NOTE:** PRESENTED AT THE 4TH INTERNATIONAL CONFERENCE ON  
AVIATION PHYSIOLOGY, SPONSORED BY THE ENVIRONMENTAL  
TECTONICS CORP. SOUTHAMPTON, PA, 11-18 OCTOBER 1985

**ABSTRACT:** OVER THE FIRST 7 DECADES OF THIS CENTURY, THE  
COMPLEXITY OF THE AIRCRAFT COCKPIT AND THE LEVEL OF PERFORMANCE OF THE  
AIRCRAFT HAVE BOTH INCREASED MANY-FOLD. MAN HAS NOT UNDERGONE A CORRESPONDING  
PERFORMANCE UPGRADE AND THE POINT HAS BEEN REACHED AT WHICH COCKPIT DESIGN  
WILL HAVE TO ALTER MARKEDLY IN ORDER TO EXPLOIT MAN'S FULL POTENTIAL AS WELL  
AS THAT OF THE AIRFRAME. THIS PAPER DISCUSSES SPECIFIC PERFORMANCE TASKING IN  
THE AIR COMBAT ENVIRONMENT, INCLUDING OFFENSIVE/DEFENSIVE MANEUVERING, WEAPON  
SELECTION/MANAGEMENT, PILOT MOBILITY, VISION, AND SITUATIONAL AWARENESS.  
PHYSIOLOGICAL EFFECTS OF HIGH ONSET RATE, HIGH SUSTAINED ACCELERATION ARE  
DISCUSSED WITH RESPECT TO THESE TASKS, INCLUDING A DISCUSSION OF THE INFLUENCE  
OF TASK DIFFICULTY AND REALISM ON THE ASSESSMENT OF PERFORMANCE.  
TECHNIQUES FOR THE ENHANCEMENT OF PERFORMANCE ARE DISCUSSED INCLUDING ANTI-G  
SUITS AND VALVES, POSTURE, PHYSIOLOGICAL SELF-PROTECTION MANEUVERS,  
POSITIVE PRESSURE BREATHING, AND PHARMACOLOGY. THIS PAPER CONCLUDES WITH A  
REVIEW AND COMPARISON OF PERFORMANCE WORK DONE IN RADICALLY RECLINED SEATS IN  
U.S. AND U.K. LABORATORIES.

## HIGH ACCELERATION COCKPIT RESEARCH

### PILOT MOBILITY IN SUPINE SEATS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The early work of Stauffer listed in the this section contains two important points:

- o Gross limb movements are not possible above about +6Gx.
- o Finger movements are still possible in the region of +12Gz.

The durations listed in this work are not surprising and probably do not represent tolerance (depending upon the actual configuration of the seat used). In any case, the durations are realistic for the real-world air combat arena. It should not be overlooked, however, that virtually any pilot can maintain consciousness in virtually any sustained acceleration level as long as it is not maintained for more than the duration of the brain blood oxygen reserve. This normally lasts for about five seconds. No one has, to the reviewer's knowledge, examined the effect of multiple, sequential very high G exposures on the duration of the brain blood oxygen reserve. Eventual compromise, reduction seems reasonable and it may well be that a supine seat with legs elevated (see below) would provide superior protection in that context.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: NA  
DTIC AD NUMBER: 620 273  
SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL

TITLE: THE EFFECT OF HIGH ACCELERATION FORCES UPON CERTAIN  
PHYSIOLOGICAL FACTORS OF HUMAN SUBJECTS PLACED IN A  
MODIFIED SUPINE POSITION

PERSONAL AUTHORS: STAUFFER, F.R.

REPORT DATE: 49/10  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL  
TECHNICAL INFORMATION SERVICE

ABSTRACT: SUBJECTS RETAINED CONSCIOUSNESS, VISION AND VOLUNTARY  
FINGER MOVEMENTS UP TO +12Gz FOR 5 TO 8 SECONDS. DIFFICULTY/DISCOMFORT IN  
RESPIRATION WAS EXPERIENCED.

ACCESSION NUMBER: NA  
DTIC AD NUMBER: ATI 86955 (AIR TECHNICAL INTELLIGENCE- A DESIGNATION  
NOW OBSOLETE)

SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL  
TITLE: COMPARATIVE EFFECTS OF HIGH RADIAL ACCELERATION ON MAN  
IN MODIFICATIONS OF THE SUPINE POSITION  
PERSONAL AUTHORS: STAUFFER F.R.  
REPORT DATE: 50/05  
REPORT SERIES NUMBER: PROJECT 001 059.02.06  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL  
TECHNICAL INFORMATION SERVICE

ABSTRACT: REPORTS THE USE OF THE SUPINE POSITION SEAT IN 4  
DIFFERENT POSTURES. THE ONE WITH THE LEGS ELEVATED PROVIDED THE BEST  
TOLERANCE: +12 TO +13Gz FOR A DURATION OF 5 SECONDS. GROSS LIMB MOVEMENTS  
WERE NOT POSSIBLE AT SUSTAINED ACCELERATION LEVELS HIGHER THAN +6Gz. FINGER  
MOVEMENTS WERE POSSIBLE AT HIGHER LEVELS.

ACCESSION NUMBER: 90-225  
SOURCE NAME: COMBINED STRESS BRANCH, ARMSTRONG LABORATORY, AL/CFBS,  
WRIGHT-PATTERSON AFB, OH 45433-6573

TITLE: A MOTION ACTIVATED ARTICULATING SEAT (MAAS) - A  
DYNAMIC CONCEPT FOR COCKPIT SEAT DESIGN IN HIGH  
PERFORMANCE AIRCRAFT

PERSONAL AUTHORS: SKOWRONSKI V.D., ESKEN R.L., COOPER J., AND KARL A.  
REPORT DATE: 90/11/21  
PAGINATION: 2  
REPORT SERIES NUMBER: SPECIAL REPORT AAMRL-SR-90-508  
SUPPLEMENTARY NOTE: ASD-90-3316

ABSTRACT: DESCRIBES THE IN-HOUSE DEVELOPMENT OF A MODERATELY  
RECLINED (30° SEATBACK ANGLE) SEAT EQUIPPED WITH A SYSTEM OF THREE  
INDIVIDUALLY INFLATABLE AIRBAGS. CONTROL OF THE AIRBAGS IS ACCOMPLISHED  
THROUGH VIDEO CAPTURE OF SPECIALLY DESIGNED SYMBOLS OR INDICATORS ON THE  
SUBJECT PILOT'S FLIGHT HELMET. THE OBJECT OF THE SYSTEM IS TO PROVIDE (VIA  
INFLATION OF THE AIRBAGS) A PHYSICAL ASSIST IN RAISING AND TURNING THE TORSO  
AND SHOULDERS TO FACILITATE "CHECKING SIX". WHEN THE VIDEO CAPTURE AND  
COMPUTER CONTROL SYSTEM RECOGNIZES (BY CHANGES IN THE HELMET MARKINGS) THAT  
THE PILOT IS ATTEMPTING TO LOOK AFT, THE APPROPRIATE AIRBAGS ARE INFLATED TO  
PROVIDE AN ASSIST. ANATOMICALLY, THIS SYSTEM IS CLAIMED TO BE SUPERIOR TO THE  
RESULTS OBTAINED WITH A "MOBILITY TEST FIXTURE" WITH A SEATBACK THAT ROTATED.  
THAT APPROACH DID NOT POSITION THE PILOT PROPERLY. THE SYSTEM HAS BEEN  
SUCCESSFULLY TESTED UNDER 1G CONDITIONS AND THE TECHNIQUE IS BEING APPLIED TO  
OTHER STUDIES IN THE LABORATORY. ALTHOUGH THE AUTHORS' ABSTRACT DOES NOT  
DESCRIBE THIS APPLICATION, IT PROBABLY CAN BE RELATED TO THE DETECTION OF HEAD  
SLUMPING/LOLLING ATTENDANT TO G-INDUCED LOSS OF CONSCIOUSNESS (GLOC G-LOC  
GLC). THIS APPLICATION WOULD BE A LOGICAL EXTENSION OF THIS ORGANIZATION'S  
EFFORTS IN THE DEVELOPMENT OF AN ARTIFICIAL INTELLIGENCE-BASED PILOT LOSS OF  
CONSCIOUSNESS MONITORING SYSTEM.

ACCESSION NUMBER: 45811  
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AS THAT OF THE AIRFRAME. THIS PAPER DISCUSSES SPECIFIC PERFORMANCE TASKING IN  
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SELECTION/MANAGEMENT, PILOT MOBILITY, VISION, AND SITUATIONAL AWARENESS.  
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DISCUSSED WITH RESPECT TO THESE TASKS, INCLUDING A DISCUSSION OF THE INFLUENCE  
OF TASK DIFFICULTY AND REALISM ON THE ASSESSMENT OF PERFORMANCE. TECHNIQUES  
FOR THE ENHANCEMENT OF PERFORMANCE ARE DISCUSSED INCLUDING ANTI-G SUITS AND  
VALVES, POSTURE, PHYSIOLOGICAL SELF-PROTECTION MANEUVERS, POSITIVE PRESSURE  
BREATHING, AND PHARMACOLOGY. THIS PAPER CONCLUDES WITH A REVIEW AND  
COMPARISON OF PERFORMANCE WORK DONE IN RADICALLY RECLINED SEATS IN U.S. AND  
U.K. LABORATORIES.

ACCESSION NUMBER: 7961  
AD: A  
AD NUMBER: 108274  
SOURCE NAME: DOUGLAS AIRCRAFT CO, LONG BEACH, CA  
  
TITLE: AIRCREW RESTRAINT AND MOBILITY TEST FIXTURE  
  
PERSONAL AUTHORS: MCDONALD, A.B.  
REPORT DATE: 81/07  
PAGINATION: 33P  
MONITOR ACRONYM: AFAMRL  
MONITOR SERIES: AFAMRL-TR-81-27

ABSTRACT: THE NEXT GENERATION COMBAT AIRCRAFT WITH ADVANCED  
AERODYNAMIC AND CONTROL FEATURES WILL HAVE COMBAT MANEUVER CAPABILITY WHICH  
WILL IMPOSE MULTIAXIAL ACCELERATIONS ON THE AIRCREW. ADVANCED AIRCREW  
SYSTEMS WILL BE REQUIRED FOR RESTRAINT, SUPPORT, AND MOBILITY DURING THESE  
COMBAT CONDITIONS. NEW CONCEPTS FOR THESE SYSTEMS HAVE BEEN DEFINED, BUT  
TESTS UNDER REPRESENTATIVE DYNAMIC CONDITIONS ARE NECESSARY TO EVALUATE THE  
EFFECTIVENESS OF THESE CONCEPTS WHEN IMPLEMENTED.

## HIGH ACCELERATION COCKPIT RESEARCH

### PILOT PERFORMANCE IN SUPINE SEATS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The literature in this section clearly underscores the fact that the benefits of reclined seats with respect to (gunnery and manikin reaction time) performance are most pronounced at levels ranging from 6 to +8Gz. Consequently, it appears reasonable to recommend that any future program of research on this issue should not be conducted at levels lower than +6Gz and probably should not deal with levels of less than +7Gz.

If it is actually established that there is a requirement for research based on anticipated future weapon system maneuver capability, it is likely that the initial emphasis should be on tolerance as opposed to performance.

With regard to the paper by Lisher and Glaister (FPRC-1362) on the use of PPB, note that this paper predates FPRC-1365, which is included in the section of this report on HAC and the use of PPB. FPRC-1365 is probably a more informative paper on the topic of PPB since that was the main objective of the later study.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 20410

TITLE: PHYSIOLOGIC AND PERFORMANCE MEASUREMENTS IN SIMULATED AIRBORNE COMBINED STRESS ENVIRONMENTS

PERSONAL AUTHORS: BOWMAN, J.S., VON BECKH, H.J.

REPORT DATE: 79/06/00

DIST/AVAIL STATEMENT: NLM-79255407 AVIAT SPACE ENVIRON MED 50 (6) P604-8  
1979 JUN JOURNAL CODE: 9JA

ABSTRACT: THE NAVAL AIR DEVELOPMENT CENTER'S HUMAN CENTRIFUGE WAS USED TO ASSESS THE EFFECTS OF REPEATED EXPOSURES TO A SIMULATED AIR COMBAT MANEUVERING (ACM) ENVIRONMENT ON VARIOUS MEASURES OF PHYSIOLOGICAL FUNCTION AND PSYCHOMOTOR PERFORMANCE. THE ENVIRONMENT CONSISTED OF A REALISTIC ACM PROFILE THAT INCLUDED ASSOCIATED NOISE, HIGH SPEED/STALL BUFFET CONDITIONS, AND INCREASED INTRA-COCKPIT TEMPERATURES. THE EFFECTS OF VARYING THE SUBJECT'S SEATBACK ANGLE, AS A FUNCTION OF THE ENVIRONMENT, WAS ALSO MEASURED. ANALYSIS OF THE VARIOUS PHYSIOLOGICAL AND PERFORMANCE DATA REVEALED THE FOLLOWING: 1) HEART RATE WAS NEGATIVELY CORRELATED WITH TRACKING ACCURACY UNDER THE COMBINED STRESS CONDITIONS OF THIS STUDY, 2) TEST CONDITIONS THAT INCLUDED ACCELERATION AND BUFFET RESULTED IN A SIGNIFICANT DECREMENT IN TRACKING ACCURACY, 3) THE ADDITION OF INCREASED INTRA-COCKPIT TEMPERATURES, WHEN COMBINED WITH ACCELERATION AND/OR BUFFET, PRODUCED A SIGNIFICANT DECREASE IN TRACKING ACCURACY, AND 4) INCREASING THE SEATBACK ANGLE FROM THE VERTICAL PARTIALLY AMELIORATED THE EFFECTS OF THE OTHER STRESSORS. DETAILS OF THESE FINDINGS, AS WELL AS RESULTS OF VARIOUS BIOCHEMICAL ANALYSES, ARE DISCUSSED. (AUTHOR)

ACCESSION NUMBER: 4684  
AD NUMBER: 783595  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB,  
OHIO

TITLE: G SUIT FILLING PRESSURES DETERMINED BY SEAT BACK ANGLE

PERSONAL AUTHORS: FRAZIER, J.W., WHITNEY, R.U., ASHARE, A.B., ROGERS,  
D.B., AND SKOWRONSKI, V.D.

REPORT DATE: 74/07  
PAGINATION: 5P  
REPORT SERIES NUMBER: AMRL-TR-74-33  
DIST/AVAIL STATEMENT: PUB. IN AEROSPACE MEDICINE, V45 N7 P755-757 JUL 74.  
NLM-74258367 JOURNAL CODE: 2RQ

ABSTRACT: A SERIES OF HUMAN CLOSED-LOOP TRACKING EXPERIMENTS  
WERE RUN ON THE DYNAMIC ENVIRONMENT SIMULATOR. PERFORMANCE WAS MEASURED AT  
LEVELS OF 4, 5, 6, 7, AND 8G WITH SEAT BACK ANGLES OF 30, 45, 55, AND 65  
DEGREES. THE G-SUIT PRESSURE SCHEDULE WAS MODIFIED FOR EACH SEAT  
CONFIGURATION BY MOUNTING THE G VALVE ON THE SEAT BACK PAN. THE PRESSURE  
SCHEDULES AND SUBJECTS' RESPONSES ARE PRESENTED. IT IS CONCLUDED THAT G SUIT  
PRESSURES CAN BE SIGNIFICANTLY REDUCED AS THE SEAT CONFIGURATION BECOMES MORE  
SUPINE.

ACCESSION NUMBER: 48740  
SOURCE NAME: ROYAL AIR FORCE INSTITUTE OF AVIATION MEDICINE,  
FARNBOROUGH, HANTS, ENGLAND

TITLE: THE EFFECT OF A RECLINED SITTING POSITION ON  
PSYCHOMOTOR PERFORMANCE DURING EXPOSURE TO HIGH,  
SUSTAINED +GZ ACCELERATION

PERSONAL AUTHORS: GLAISTER, D.H., AND LISHER, B.J.

REPORT DATE: 77/07  
PAGINATION: 26P  
REPORT SERIES NUMBER: FPRC-1362

ABSTRACT: BY USE OF A TWO-AXIS ADAPTIVE TRACKING TASK,  
PSYCHOMOTOR PERFORMANCE WAS MEASURED IN 12 SUBJECTS (6 OF THEM PILOTS) AT UP  
TO 8 GZ, EITHER SEATED IN A CONVENTIONAL EJECTION SEAT, OR RECLINED WITH THE  
BACK SUPPORTED 60 DEG FROM THE VERTICAL IN ORDER TO DETERMINE THE INFLUENCE OF  
SEAT BACK ANGLE ON PILOT IN-FLIGHT PERFORMANCE. SUBJECTS WORE ANTI-G SUITS  
AND PRESSURE BREATHED DURING ACCELERATION. RECLINATION LED TO AN IMPROVEMENT  
IN PERFORMANCE AT +6GZ AND +8GZ, THE BENEFIT BEING EQUIVALENT TO BETWEEN  
1 AND +2GZ. HEART RATES WERE REDUCED BY RECLINATION, THE AVERAGE RATE  
RECORDED AT +8GZ WHEN RECLINED BEING SIMILAR TO THAT AT +5GZ WHEN SEATED  
CONVENTIONALLY.

ACCESSION NUMBER: 45116  
AD: B

**AD NUMBER:** 034784

**SOURCE NAME:** FLYING PERSONNEL RESEARCH COMMITTEE, RAF INSTITUTE OF AVIATION MEDICINE, FARNBOROUGH, HANTS, ENGLAND

**TITLE:** THE EFFECT OF ACCELERATION AND SEAT BACK ANGLE ON PERFORMANCE OF A REACTION TIME TASK

**PERSONAL AUTHORS:** LISHER, B.J., AND GLAISTER, D.H.

**REPORT DATE:** 78/03/11

**PAGINATION:** 17P

**REPORT SERIES NUMBER:** FPRC-1364

**ABSTRACT:** IT IS CONCLUDED THAT ONLY A LARGE ANGLE OF SUPINATION (I.E., 67 DEGREES FROM THE ACCELERATION VECTOR) WILL BE A SOUND BASIS FOR A HIGH ACCELERATION COCKPIT. A 65° SEAT BACK ANGLE WAS FOUND SUPERIOR TO EITHER 17° or 52° SEATS AND PROVIDED 1.4GZ OF PROTECTION. PERFORMANCE WAS MEASURED USING A MANIKIN REACTION TIME TASK.

**ACCESSION NUMBER:** 4236

**AD NUMBER:** 042950

**SOURCE NAME:** AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB, OHIO

**TITLE:** PILOT TRACKING PERFORMANCE AS A FUNCTION OF G STRESS AND SEAT BACK ANGLE.

**PERSONAL AUTHORS:** MCELREATH, K.W., AND CLADER, M.D.

**REPORT DATE:** 77/05

**PAGINATION:** 17P

**REPORT SERIES NUMBER:** AMRL-TR-76-107

**ABSTRACT:** THE RESULTS SHOW DEGRADED WEAPON TRACKING AT ELEVATED G LEVELS. IMPROVED SUBJECT TOLERANCE AND GREATER KILL OPPORTUNITY DUE TO SEAT BACK ANGLE ARE PRESENTED AT +8GZ AND ABOVE. THE DATA WERE NOT SUFFICIENT TO ALLOW MODELING OF THE TRACKING PERFORMANCE AS A FUNCTION OF SEAT BACK ANGLE BUT DID SHOW A THRESHOLD EFFECT IN THE +6-8GZ REGION ON PILOT TRACKING CAPABILITY.

**ACCESSION NUMBER:** 4764

**AD NUMBER:** 770271

**SOURCE NAME:** AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB, OHIO

**TITLE:** EFFECT OF MODIFIED SEAT ANGLE ON AIR TO AIR WEAPON SYSTEM PERFORMANCE UNDER HIGH ACCELERATION.

**PERSONAL AUTHORS:** ROGERS, D.B., ASHARE, A.B., SMILES, K.A., FRAZIER, J.W., AND SKOWRONSKI, V.D.

**REPORT DATE:** 73/07



PAGINATION: 18P  
REPORT SERIES NUMBER: REPT NO. AMRL-TR-73-5  
ABSTRACT: IN AIR-TO-AIR COMBAT, THE WEAPONS SYSTEM THAT HAS THE HIGHEST AGILITY AND G MANEUVERING CAPABILITY HAS A DECIDED ADVANTAGE OVER A LESS CAPABLE SYSTEM. A METHOD OF INCREASING THE G TOLERANCE OF THE HUMAN PORTION OF THE SYSTEM IS THE USE OF RECLINING SEATS. THE MODIFIED CLOSED LOOP DYNAMIC ENVIRONMENT SIMULATOR SYSTEM WAS EMPLOYED AS THE EXPERIMENTAL TEST BED FOR INVESTIGATION OF CENTRIFUGE PILOTS IN THE RECLINED POSITION. THE CENTRIFUGE PILOTS WERE REQUIRED TO FLY THROUGH A SERIES OF G ON G COMBAT MANEUVERS AND TO PERFORM TARGET LOCK-ON AND BORESIGHT CANNON FIRING THROUGH A PREDICTIVE GUNSIGHT RETICLE AT A PROJECTED ENEMY AIRCRAFT. THE PERFORMANCE SCORING WAS MEASURED AS NUMBER OF BALLISTIC ROUNDS DELIVERED ON THE TARGET.

ACCESSION NUMBER: 4830  
AD NUMBER: 755636  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB, WRIGHT-PATTERSON AFB, OHIO

TITLE: PERFORMANCE MEASUREMENT USING PILOT CONTROLLED GZ MANEUVERING WITH A SIMULATED OPERATIONAL TASK

PERSONAL AUTHORS: ROGERS, D.B., HOLDEN, F.M., REPLOGLE, C.R., POTOR, G., DAY, C.N., VAN PATTEN, R.E., SMILES, K.A., AND MOHR, G.C.

REPORT DATE: 72/06  
PAGINATION: 6P  
REPORT SERIES NUMBER: AMRL-72-3; AGARD-CPP-101  
SUPPLEMENTARY NOTE: AGARD CONFERENCE, AEROSPACE MEDICAL PANEL SPECIALIST MEETING, 2 JUNE 1972, BRUSSELS, BELGIUM  
DIST/AVAIL STATEMENT: ALSO PUB. IN AGARD CONFERENCE PREPRINT NO. 101 ON PERFORMANCE AND BIODYNAMIC STRESS-INFLUENCE OF INTERACTING STRESSES ON PERFORMANCE, PC11-1-C11-5. (ACCESSION NO 1077)

ABSTRACT: A TECHNIQUE FOR HUMAN PERFORMANCE MEASUREMENT USING A CLOSED LOOP CENTRIFUGE WAS VALIDATED. THE STUDY WAS PERFORMED ON THE DYNAMIC ENVIRONMENT SIMULATOR (DES) OPERATING IN A CLOSED LOOP MODE. THE SIMULATION UTILIZED THE PITCH AND ROLL DYNAMICS OF A HIGH PERFORMANCE AIRCRAFT. THE MEASUREMENT CRITERION WAS HITS ON TARGET USING A DISPLAY GENERATED HEADS UP GUNSIGHT ON A MANEUVERING TARGET AIRCRAFT. AN IMPORTANT CONSIDERATION WAS RELATIONSHIP BETWEEN MAN AS A PASSIVE RIDER VERSUS MAN AS AN ACTIVE PARTICIPANT IN THE GENERATION OF THE GZ STRESS. TWO IMPORTANT DEMONSTRATIONS RESULTING FROM THIS STUDY ARE: (1) THERE IS A SIGNIFICANT DIFFERENCE IN THE ABILITY OF SUBJECT PILOTS TO PERFORM IN CLOSED VERSUS OPEN LOOP CONFIGURATION, AND (2) IT IS FEASIBLE TO PROVIDE A MISSION RELATED HUMAN PERFORMANCE METRIC IN A SELECTIVE SIMULATION IN WHICH THE +GZ FORCES ARE DYNAMICALLY REALISTIC. A PREDICTIVE HEADS UP GUNSIGHT DISPLAY IS UTILIZED WITH TARGET TRAJECTORIES REPRESENTATIVE OF AERIAL COMBAT MANEUVERS; AND ON LINE PERFORMANCE MEASURES AND IMMEDIATE PERFORMANCE FEEDBACK ARE PROVIDED.

ACCESSION NUMBER: 4613

**AD NUMBER:** 913694  
**SOURCE NAME:** MCDONNELL AIRCRAFT CO., ST LOUIS, MO  
**TITLE:** ADVANCED FIGHTER CONCEPTS INCORPORATING HIGH ACCELERATION COCKPITS. VOLUME IV. PILOT PERFORMANCE ANALYSES.  
**PERSONAL AUTHORS:** SINNETT, J.M., AND ASIALA, C.F.  
**REPORT DATE:** 73/07  
**PAGINATION:** 154P  
**REPORT SERIES NUMBER:** MDC-A1685-VOL-4  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-72-116  
**SUPPLEMENTARY NOTE:** SEE ALSO VOLUME 5, AD-913 695L.

**ABSTRACT:** THE STUDY INVESTIGATED PILOT PERFORMANCE ENHANCEMENT (THROUGH APPLICATION OF AN ARTICULATED SEAT CONCEPT) AS RELATED TO PILOT TASK WORKLOAD IN A HIGH G COMBAT ENVIRONMENT. THE APPROACH TAKEN TO SATISFY SEVERAL STUDY OBJECTIVES WAS UTILIZATION OF THE MCDONNELL DOUGLAS CORPORATION PILOT SIMULATION MODEL. THIS MODEL DEPICTED ALL OF THE DETAILED PILOT FUNCTIONS, THEIR INTERRELATIONSHIPS AND THE POTENTIAL ALTERNATE OR ITERATING LOOPS. AS A RESULT OF INTERFACING WITH AIR BATTLE SIMULATION II MODEL, AIR BATTLE KINEMATICS AND DYNAMIC SEQUENCING ENABLED THE DEFINITION OF PILOT TASK AND TASK LOADING DURING COMBAT ENGAGEMENTS. THE INTERACTION BETWEEN THE MODELS, ADVANCED SYSTEM DESIGN AND INTEGRATION AND VERIFICATION OF THE FEASIBILITY USING SIMULATOR DESIGN AID PROVIDED A NEAR TERM, ADVANCED HIGH ACCELERATION CREW STATION DESIGN.

**ACCESSION NUMBER:** 7880  
**AD:** A  
**AD NUMBER:** 145439  
**SOURCE NAME:** AF AEROSPACE MEDICAL RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH

**TITLE:** THE HIGH ACCELERATION COCKPIT (HAC): A TECHNOLOGY BASE OVERVIEW - 1983

**PERSONAL AUTHORS:** VAN PATTEN, R.E., JENNINGS, T.J., AND MAXWELL, M.

**REPORT DATE:** 83/06  
**PAGINATION:** 5P  
**REPORT SERIES NUMBER:** AFAMRL-TR-84-075  
**SUPPLEMENTARY NOTE:** SAFE ASSOCIATION MEETING, 5-8 NOV 83, SAN ANTONIO TX  
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**PAGINATION:** 12P  
**SUPPLEMENTARY NOTE:** PRESENTED AT THE 4TH INTERNATIONAL CONFERENCE ON AVIATION PHYSIOLOGY, SPONSORED BY THE ENVIRONMENTAL TECTONICS CORP., SOUTHAMPTON, PA, 11-18 OCTOBER 1985

**ABSTRACT:** OVER THE FIRST SEVEN DECADES OF THIS CENTURY, THE COMPLEXITY OF THE AIRCRAFT COCKPIT AND THE LEVEL OF PERFORMANCE OF THE AIRCRAFT HAVE BOTH INCREASED MANY-FOLD. MAN HAS NOT UNDERGONE A CORRESPONDING PERFORMANCE UPGRADE AND THE POINT HAS BEEN REACHED AT WHICH COCKPIT DESIGN WILL HAVE TO ALTER MARKEDLY IN ORDER TO EXPLOIT MAN'S FULL POTENTIAL AS WELL AS THAT OF THE AIRFRAME. THIS PAPER DISCUSSES SPECIFIC PERFORMANCE TASKING IN THE AIR COMBAT ENVIRONMENT, INCLUDING OFFENSIVE/DEFENSIVE MANEUVERING, WEAPON SELECTION/MANAGEMENT, PILOT MOBILITY, VISION, SITUATIONAL AWARENESS. PHYSIOLOGICAL EFFECTS OF HIGH ONSET RATE, HIGH SUSTAINED ACCELERATION ARE DISCUSSED WITH RESPECT TO THESE TASKS, INCLUDING A DISCUSSION OF THE INFLUENCE OF TASK DIFFICULTY AND REALISM ON THE ASSESSMENT OF PERFORMANCE. TECHNIQUES FOR THE ENHANCEMENT OF PERFORMANCE ARE DISCUSSED INCLUDING ANTI-G SUITS AND VALVES, POSTURE, PHYSIOLOGICAL SELF-PROTECTION MANEUVERS, POSITIVE PRESSURE BREATHING, AND PHARMACOLOGY. THIS PAPER CONCLUDES WITH A REVIEW AND COMPARISON OF PERFORMANCE WORK DONE IN RADICALLY RECLINED SEATS IN U.S. AND U.K. LABORATORIES.

**ACCESSION NUMBER:** 47627  
**SOURCE NAME:** ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH

**TITLE:** EFFECT OF SEAT CONFIGURATION ON PILOT TRACKING AND GUNNERY PERFORMANCE FOLLOWING REPETITIVE EXPOSURE TO HIGH +GZ ACCELERATION

**PERSONAL AUTHORS:** WEST, A.K., MCELREATH, K.W., AND KIRKLAND, J.S.  
**PAGINATION:** 18P  
**REPORT SERIES NUMBER:** PROTOCOL 75-42  
**DESCRIPTIVE NOTE:** EXPERIMENTAL PROTOCOL

**ABSTRACT:** PREVIOUS CENTRIFUGE STUDIES CONDUCTED BY AMRL/EM HAVE VALIDATED THE PERFORMANCE PAYOFF OF RECLINED SEATS UNDER HIGH +GZ ACCELERATION STRESS. THE PUBLISHED RESULTS OF THAT RESEARCH HAVE BEEN WIDELY USED IN A VARIETY OF DIGITAL AND MAN-IN-THE-LOOP AIR COMBAT SIMULATIONS, AND PROVIDED THE MAIN RATIONALE FOR AFFDL TO INITIATE A HIGH ACCELERATION COCKPIT (HAC) ADVANCED DEVELOPMENT PROGRAM.

## HIGH ACCELERATION COCKPIT RESEARCH

### POSITIVE PRESSURE BREATHING AND ASSISTED POSITIVE PRESSURE BREATHING

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

There appears to be a paucity of research conducted up through the end of CY-1992 on this topic. What literature is available indicates that PPB is effective and beneficial in reclined seats, with certain caveats. No literature concerning the use of assisted positive pressure breathing with reclined seats has been located.

In summary, the Burns paper does not report any research on the combined effects of the simultaneous use of a reclined seat and APPB at a pressure of 60mm Hg. This paper is a review article and speculates on the potential for enhanced protection with this combination of modalities.

The papers by Lisher and Glaister provide more information on this topic. At the outset, they state that the seat they used was of such a design to provide adequate forward vision and state that the head was erect. The authors cite their earlier work in which they proposed a cosine model for the protection afforded by reclined seats. This model is in general agreement with the earlier work of Holden and Rogers. The actual seatback angle was  $65^{\circ}$  from the vertical which would lead to an expectation that the Z component of the total vector would have been about 42%. The buttocks and thighs were supported on the horizontal plane, while the legs were positioned  $30^{\circ}$  below the horizontal plane. It is reported that this reclined seat alone provided 1.4GZ. With the addition of anti-G suit inflation (maximum schedule 1.25PSIG\*G-1), the protection rose to between +2.4 and +3GZ. With the addition of the anti-G suit and PPB, the level of protection rose to between +3.4 and +4GZ. The PPB pressure schedule was 5mm Hg/G up to a maximum of approximately 35mm Hg. The reported range of tolerance was +6Gz to +8.6Gz with a mean of +7.4Gz. Note that the tolerance endpoint was relaxed greyout threshold. It should be noted that there is some uncertainty about the real meaning of a "relaxed greyout threshold" when subjects are using PPB.

If it is assumed that any adequately trained pilot can perform a 100mmHg anti-G straining maneuver (AGSM), then it appears likely that the methodology (reclined seat/erect head, anti-G suit, and PPB) used here combined with a 100mmHg AGSM (or perhaps a lesser AGSM combined with APPB at a higher pressure) would be likely to result in a greyout threshold in the range from +10 to +12.6Gz. This would represent a level of protection in excess of that required for any fighter aircraft now in operational service or known to be planned.

It is interesting to note that in this early work the authors encountered some of the problems that currently trouble the development of PPB and anti-G suits. One of their subjects complained of ear inflation pain, and another complained of severe arm pain and exhibited marked petechiae. The authors take note of this describing the first as simply a hazard of the use of PPB, and the second as possibly amenable to correction by modifications to the anti-G suit to provide protection to the arms (which would, incidentally, enhance the performance of the anti-G suit). Deployment of the Air Force's

COMBAT EDGE PPB system have resulted in relatively few aeromedical problems (Travis 92/5).

Consequently, it is suggested that a useful avenue of research would be directed toward further study of a seat of this type to determine if this level of protection can be duplicated with straining subjects, using standard anti-G suit inflation schedules combined with APPB in a high onset rate environment. This program of research should be approached incrementally so as to be able to define the contribution of each element of the protective measures. The question of the benefit of raising the legs above the horizontal (to the extent practical with regard to forward vision) should also be addressed.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: NA  
SOURCE NAME: AVIAT. SPACE ENVIRON. MED 1988; 59:20-2

TITLE: PREVENTION OF LOSS OF CONSCIOUSNESS WITH POSITIVE PRESSURE BREATHING AND SUPINATING SEAT

PERSONAL AUTHORS: BURNS, J.W.

REPORT DATE: 87/01  
PAGINATION: 3  
SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: A REVIEW ARTICLE SPECULATING ON THE ADVANTAGES OF RECLINED HAC SEATS COMBINED WITH POSITIVE PRESSURE BREATHING. REPORTS RELAXED TOLERANCE OF +5.9Gz USING ASSISTED POSITIVE PRESSURE BREATHING (APPB) AT 60 MM HG (ONLY IN CONVENTIONAL SEAT).

ACCESSION NUMBER: 46670  
SOURCE NAME: THE PATHOPHYSIOLOGY OF HIGH SUSTAINED +GZ ACCELERATION, LIMITATION TO AIR COMBAT MANEUVERING AND THE USE OF CENTRIFUGES IN PERFORMANCE TRAINING

TITLE: CENTRIFUGE ASSESSMENT OF A RECLINING SEAT

PERSONAL AUTHORS: GLAISTER, D.H., AND LISHER, B.J.

REPORT DATE: 76/10  
PAGINATION: 8P  
REPORT SERIES NUMBER: NATO AGARD-CP-189  
DIST/AVAIL STATEMENT: NTIS

ABSTRACT: A RECLINING SEAT HAS BEEN BUILT WHICH WOULD GIVE A PILOT A SIGNIFICANT INCREASE IN ACCELERATION TOLERANCE WHILST MAINTAINING ADEQUATE FORWARD VISION. THE EFFECT OF ANTI-G SUIT INFLATION HAS BEEN INVESTIGATED USING THREE DIFFERENT PRESSURE REGIMENS, AND POSITIVE PRESSURE BREATHING (PPB) HAS BEEN USED TO COUNTER THE ADDED INSPIRATORY EFFORT

WHICH RESULTED FROM THE CONSIDERABLE +GX ACCELERATION VECTOR. THE RECLINING SEAT ALONE GAVE AN INCREASE IN TOLERANCE OF 1.4GZ WHEN COMPARED WITH A CONVENTIONAL SEAT; ANTI-G SUIT INFLATION AFFORDED A FURTHER +1.0 TO +1.6GZ; AND PPB A FURTHER +1.0GZ. THE COMBINATION LED TO RELAXED GREYOUT THRESHOLDS WHICH AVERAGED +7.4GZ (RANGE +6.0 TO +8.6GZ) IN 9 SUBJECTS. PPB PRODUCED A SIGNIFICANT INCREASE IN VITAL CAPACITY AND RESTORED THE EXPIRATORY RESERVE VOLUME TO NEAR NORMAL LEVELS. SUBJECTIVELY, BREATHING BECAME MUCH EASIER. THE CLOSING VOLUME OF THE LUNG WAS INCREASED BY ACCELERATION, BUT WAS NOT SIGNIFICANTLY AFFECTED BY PPB. HOWEVER, THE INCREASE IN EXPIRATORY VOLUME WITH PPB SHOULD LEAD TO LESS AIRWAY CLOSURE DURING TIDAL BREATHING, WITH A CONSEQUENT INCREASE IN ARTERIAL OXYGEN LEVELS AND A DECREASED SUSCEPTIBILITY TO ACCELERATION ATELECTASIS. IT IS CONSIDERED THAT A SEAT IN WHICH A NEAR SUPINE POSITION IS ADOPTED WITH RESPECT TO THE GZ VECTOR, WHEN USED IN CONJUNCTION WITH AN ANTI-G SUIT AND POSITIVE PRESSURE BREATHING, WILL RESULT IN A G TOLERANCE WHICH IS IN MORE ACCORD WITH THE PERFORMANCE OF MODERN MILITARY AIRCRAFT.

ACCESSION NUMBER: 47461  
 SOURCE NAME: PUBLISHED IN: AVIATION MEDICINE, ARTICLES FROM THE  
 BRITISH MEDICAL JOURNAL, PGS 38-47, 1983  
 TITLE: EFFECTS OF SUSTAINED ACCELERATION ON THE CIRCULATION  
 PERSONAL AUTHORS: GLAISTER, D.H.  
 REPORT DATE: 85/10/11  
 PAGINATION: 12P  
 SUPPLEMENTARY NOTE: PRESENTED AT THE FOURTH ANNUAL INTERNATIONAL  
 CONFERENCE ON AVIATION PHYSIOLOGY, AEROMEDICAL  
 TRAINING INSTITUTE, SOUTHAMPTON, PA, 11-18 OCTOBER  
 1985 (SEE ACCESSION NO. 47275)  
 DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: THE EFFECTS OF SUSTAINED ACCELERATION ON THE  
 CIRCULATION WILL COVER THE FOLLOWING TOPICS: THE DEFINITION OF G AND ITS  
 VECTORS; HYDROSTATIC PRESSURE GRADIENTS AND THE CONCEPT OF A LEVEL OF  
 HYDROSTATIC INDIFFERENCE; BLOOD POOLING AND TRANSUDATION; REDUCED VENOUS  
 RETURN AND CARDIAC OUTPUT; THE APPLICATION OF STARLING RESISTOR THEORY  
 TO THE CEREBRAL CIRCULATION AND LOSS OF CONSCIOUSNESS; THE RETINAL  
 CIRCULATION, GREYOUT AND BLACKOUT; PHYSIOLOGICAL COMPENSATORY MECHANISMS AND  
 DISTRIBUTION OF CARDIAC OUTPUT; PRINCIPLES OF PROTECTION AGAINST +GZ  
 ACCELERATION (ANTI-G SUIT, BREATHING MANEUVERS, POSITIVE PRESSURE BREATHING,  
 RECLINING SEAT); SUSTAINED ACCELERATION TOLERANCE LIMITS.

ACCESSION NUMBER: NA  
 SOURCE NAME: RAAF INSTITUTE OF AVIATION MEDICINE, FLYING PERSONNEL  
 RESEARCH COMMITTEE, FARNBOROUGH, HANTS, UK  
 TITLE: THE INFLUENCE OF SEATBACK ANGLE ON ACCELERATION  
 TOLERANCE  
 PERSONAL AUTHORS: GLAISTER, D.H.  
 REPORT DATE: 78/03

REPORT SERIES NUMBER: FPRC-1365  
SUPPLEMENTARY NOTE: TECHNICAL REPORT  
DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: STUDIED SEATBACK ANGLES OF 58°, 69°, AND 74°. DEVELOPED MODEL FOR RELATIONSHIP BETWEEN TOLERANCE AND SEATBACK ANGLE:  $TOLERANCE = A+B/COSX$ , WHERE X IS THE ANGLE BETWEEN THE VERTICAL AND SEATBACK. RESULTS SIMILAR TO EARLIER WORK OF HOLDEN AND ROGERS. PPB WAS NOT EMPLOYED IN THIS STUDY AND IS INCLUDED IN THIS SECTION FOR CONVENIENCE OF THE READER.

ACCESSION NUMBER: NA  
SOURCE NAME: AVIAT. SPACE AND ENVIR. MED., VOL 63, NO. 5, MAY 1992, PG 389.

TITLE: THE INCIDENCE OF ACUTE ADVERSE HEALTH EFFECTS IN PILOTS USING POSITIVE-PRESSURE BREATHING ANTI-G SYSTEM (PBG)

PERSONAL AUTHORS: TRAVIS, T.W.

REPORT DATE: 92/5  
PAGINATION: 1P  
SUPPLEMENTARY NOTE: ABSTRACT FROM ASMA 63RD ANNUAL SCIENTIFIC MEETING. AUTHOR ALSO PRESENTED MATERIAL AT 1992 NAECON CONFERENCE IN DAYTON, OH, TITLED "G-LOC AND THE TACTICAL FIGHTER PILOT"

DIST/AVAIL STATEMENT: VIDEO TAPE OF NAECON LECTURE CAN BE OBTAINED FROM BILL ALBERY, COMBINED STRESS BRANCH, ARMSTRONG LABORATORY, WRIGHT-PATTERSON AFB, OH

ABSTRACT; THE AUTHOR LOOKS AT THE INCIDENCE OF G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC) SINCE 1982 AND THE STRATEGY THE AIR FORCE HAS TAKEN TO DECREASE THE INCIDENCES OF G-LOC BY DEVELOPING COMBAT EDGE. THE COMBAT EDGE ENSEMBLE CONSISTS OF THE CONVENTIONAL G-SUIT AND VALVE WITH POSITIVE PRESSURE BREATHING DURING G (PBG) ASSISTED BY A COUNTER-PRESSURE VEST. THIS ENSEMBLE UNDER WENT OPERATIONAL TESTING AND EVALUATION IN THE F-15 AND F-16. OCCURRENCES OF NECK PAIN, BACK PAIN, ARM PAIN, GRAY-OUT, BLACK-OUT, G-LOC, DYSPNEA, AND COUGHING DURING HIGH-G FLIGHT WERE COMPARED BETWEEN PILOTS WITH AND WITHOUT THE COMBAT EDGE SYSTEM. THE AUTHOR CONCLUDES THAT PBG DOES NOT APPEAR TO BE UNSAFE WITH REGARD TO THE VARIABLES JUST MENTIONED BUT THAT LONG-TERM STUDIES SHOULD CONTINUE.

## HIGH ACCELERATION COCKPIT RESEARCH

### PRONATION/PRONE POSITION

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The issue of whether to pursue supination or pronation in the quest for the ultimate in G protection is one that should be settled prior to commencement of any future program of research. It is clear from the reports cited in the following that the prone position appears to offer a less painful method for the attainment of very high G tolerance (the water filled capsule work is largely irrelevant in the operational sense). Note that extended endurance to levels ranging from +10 to +15Gz was obtained in the early work with the prone position.

The concept is so radical, and the problems of head support and aftward vision are so pervasive that these represent formidable obstacles in convincing the operational community of the relevance of the idea. The work of Adams, which cannot be described in this report because of proprietary considerations, represents a middle ground in the prone versus supine controversy and should certainly be examined in detail prior to a final decision on the structure of any future HAC research program.

The Prone Escape System (PRESS) concept is interesting in terms of having generated a rather thorough investigation of the possibilities inherent in approaches involving a pronating seat as opposed to a fully prone installation. On the evidence provided by the authors, however, the PRESS concept as proposed does not appear to offer more than about a half +Gz of protection and hardly seems worth testing on that basis.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 7219  
AD NUMBER: 005352  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LABS, WRIGHT-PATTERSON AFB, OHIO

TITLE: THE EFFECTS OF PROLONGED ACCELERATION ON THE HUMAN BODY IN THE PRONE AND SUPINE POSITIONS

PERSONAL AUTHORS: BALLINGER, E.R., AND DEMPSEY, C.A.

REPORT DATE: 52/07  
PAGINATION: 1 VOLUME

ABSTRACT: TWO ACCELERATION PROBLEMS OF EQUAL INTEREST WERE STUDIED SIMULTANEOUSLY ON THE WRIGHT AIR DEVELOPMENT CENTER HUMAN CENTRIFUGE AT THE AERO MEDICAL LABORATORY. DATA WERE OBTAINED IN REGARD TO BOTH THE EVALUATION OF THE PRONE BED AT VARIOUS ACCELERATIONS AND THE CONCOMITANT DETERMINATION OF THE PHYSIOLOGICAL TOLERANCE TO PROLONGED PERIODS OF ACCELERATION IN SEMIPRONE AND SUPINE POSITIONS. THE DURATION OF RUNS DEPENDED UPON THE ACCELERATION, RANGING FROM 15 MINUTES AT +3 GZ, 8 MINUTES AT +4 GZ,



ETC., TO 2 MINUTES AT +10 GZ. THERE WAS NO APPRECIABLE DIFFERENCE IN TOLERANCE IN THE SEMI-PRONE OR SUPINE POSITIONS WITH ACCELERATIONS UP TO +10 GZ. HOWEVER, THE NECESSITY FOR A WELL-CONSTRUCTED BED AND HEAD-SUPPORTING HELMET, PRIMARILY FOR THE COMFORT OF THE SUBJECT, WAS REPEATEDLY DEMONSTRATED. IN PROPERLY DESIGNED PRONE AND SUPINE BEDS, 23 UNPROTECTED SUBJECTS WERE ABLE TO TOLERATE ACCELERATION UP TO +10 GZ FOR 2 MINUTES WITH ONLY A SMALL AMOUNT OF DISCOMFORT.

ACCESSION NUMBER: NA  
SOURCE NAME: AIR FORCE INSTITUTE OF TECHNOLOGY  
TITLE: PRONE ESCAPE SYSTEM (PRESS) DESIGN STUDY  
PERSONAL AUTHORS: DISSELKOEN, A.D., GARGIULO, R.F., HAYWOOD, J.E.,  
HEISE, K.H., HOLCOMB, D.H., MILLER, G.R., NICHOLSON,  
J.S., AND OLINGER, J.J.  
REPORT DATE: 87/12  
PAGINATION: 200 APPROX.  
REPORT SERIES NUMBER: AFIT/GSE/AA/87D-2  
SUPPLEMENTARY NOTE: THESIS-MS IN SYSTEMS ENGINEERING  
DIST/AVAIL STATEMENT: DISTRIBUTION LIMITED TO US GOVERNMENT AGENCIES AND  
THEIR CONTRACTORS; CRITICAL TECHNOLOGY. OTHER  
REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO THE  
ESCAPE AND IMPACT PROTECTION BRANCH, AL/CFBE, WRIGHT-  
PATTERSON AFB, OH 45433-6571

ABSTRACT: FUTURE FIGHTER AIRCRAFT WILL SUSTAIN MORE G-FORCES THAN A PILOT CAN TOLERATE. THE PRONE (FORWARD LEANING) FLYING POSITION OFFERS ENHANCED PILOT G-TOLERANCE AND IS BEING CONSIDERED IN FUTURE FIGHTER DESIGNS. THIS THESIS DESIGN TEAM INVESTIGATED EJECTION FROM A PRONE POSITION. FIRST, A FEASIBLE PRONE FIGHTER SEAT WAS DESIGNED. IT WAS THEN DIMENSIONED TO FIT THE 5TH TO 95TH PERCENTILE PILOT WITH A HUMAN FACTORS ANALYSIS, AND REFINED USING THE ROMULUS CAD PROGRAM. A COMPLETE AERODYNAMIC ANALYSIS, USING THE MARK IV SUPERSONIC-HYPERSONIC ARBITRARY BODY COMPUTER PROGRAM, SHOWED STATIC STABILITY IN THE WINDSTREAM. A CATAPULT/SUSTAINER ROCKET PROPULSION AND CONTROL SYSTEM WAS DESIGNED TO POSITION THE SEAT AT ITS AERODYNAMIC STABILITY ANGLE OF ATTACK. FINALLY, THE EASIEST SIMULATION PACKAGE WAS USED TO SIMULATE PRESS EJECTIONS THROUGHOUT THE EJECTION ENVELOPE UP TO AN ALTITUDE OF 70,000 FEET, A DYNAMIC PRESSURE OF 2000 PSF AND AN AIRSPEED OF MACH 3. PRESS'S ADVANTAGES OVER CONVENTIONAL EJECTION SYSTEMS ARE AN EXPANDED EJECTION ENVELOPE, INCREASED CATAPULT G-FORCE PROTECTION, WINDBLAST PROTECTION, AND STABILITY IN THE WINDSTREAM (AUTHORS). THE APPROACH TAKEN IN THIS STUDY IS BASED UPON A SEAT DESIGNED TO SUPPORT THE PILOT IN A POSTURE IN WHICH HE LEANS FORWARD TO A PLANE 35° FORWARD OF THE VERTICAL. ACCORDING TO AN ANALYSIS ON PAGE 5.9 OF THE THESIS THIS POSTURE REDUCES THE EYE-HEART DISTANCE FROM ABOUT 33CM TO 22CM WHICH EQUATES TO A GAIN IN TOLERANCE OF 10/22G, OR 0.45G. IN VIEW OF THE COMPLEXITY OF THIS KIND OF DESIGN, THE GAIN DOES NOT APPEAR TO BE WORTH THE EFFORT. THE AUTHORS NOTE THAT PILOTS WHO WERE ASKED TO EVALUATE THE CONCEPT STATED THAT A FORWARD ANGLE IN EXCESS OF 45° WAS VERY UNCOMFORTABLE. ACCORDINGLY, THE ACCELERATION PROTECTIVE ASPECT OF THIS DESIGN APPEARS TO BE SEVERELY LIMITED AND THE FULLY PRONE POSITION REMAINS THE ONLY METHOD OF

EXPLOITING THE FULL POTENTIAL OF THE CONCEPT. THE AUTHORS OF THIS STUDY NOTED THIS, BUT WERE PUT OFF BY THE RADICAL NATURE AND COMPLEXITY OF A FULLY PRONE POSITION (EDITOR).

ACCESSION NUMBER: 3268  
AD NUMBER: 020518  
SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA, AVIATION MEDICAL ACCELERATION LAB

TITLE: SOME OBSERVATIONS ON HUMAN TOLERANCE TO EXPOSURES OF 15 TRANSVERSE G

PERSONAL AUTHORS: DUANE, T.D., AND BECKMAN, E.L.

REPORT DATE: 53/07/30  
PAGINATION: 1 VOLUME  
REPORT SERIES NUMBER: NADC-MA-5305

ABSTRACT: FIVE SUBJECTS WERE EXPOSED TO 15 TRANSVERSE ( $G_x$ ) FOR FIVE SECONDS IN THE SUPINE POSITION. ALSO, FIVE SUBJECTS WERE PLACED IN THE PRONE POSITION AND EXPOSED TO THE SAME ACCELERATIVE CONDITIONS. BLACKOUT AND UNCONSCIOUSNESS DID NOT OCCUR AND THE PHYSIOLOGICAL EFFECTS PRODUCED WERE OF A TRANSIENT NATURE. AN ADEQUATELY STRESSED SEAT WAS SUFFICIENT PROTECTION FOR THE SUPINE POSITION. SINCE THE CONVENTIONAL SHOULDER HARNESS AND LAP BELT WERE NOT SUITABLE FOR LEVELS ABOVE 7 GZ WHEN THE STRESS WAS APPLIED IN THE PRONE POSITION, ADDITIONAL THORAX AND LEG BARRIERS WERE EMPLOYED.

ACCESSION NUMBER: 48786  
SOURCE NAME: U.S. NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA

TITLE: TESTS OF WATER-FILLED CAPSULE IN PRONE POSITION

PERSONAL AUTHORS: GRAY, R.F., AND WEBB, M.G.

REPORT DATE: 59/04/13  
PAGINATION: 7P  
REPORT SERIES NUMBER: NADC-MA-5-2933  
DESCRIPTIVE NOTE: LETTER REPORT

ABSTRACT: THE AVIATION MEDICAL ACCELERATION LABORATORY (AMAL) G-CAPSULE IS A DEVICE TO PROTECT HUMANS AGAINST THE BODY DISTORTION EFFECTS OF HIGH ACCELERATION FORCES. WATER IS USED TO CLOSELY COUPLE THE OUTSIDE OF THE PERSON'S BODY TO THE RIGID CONTAINER. ONE SUBJECT HAS GONE TO 31 GZ IN THE CAPSULE, WHICH IS THE MAXIMUM PRESENTLY ATTAINABLE ON THE AMAL CENTRIFUGE. THE LIMITS OF TOLERANCE WERE NOT REACHED.

ACCESSION NUMBER: 48785  
SOURCE NAME: U.S. NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA

TITLE: PRELIMINARY STUDY OF G TOLERANCE OF A SUBJECT IN THE G-CAPSULE, PRONE POSITION

PERSONAL AUTHORS: GRAY, R.F., AND WEBB, M.G.

REPORT DATE: 58/07/08

PAGINATION: 9P

REPORT SERIES NUMBER: NADC-MA-5-0568

DESCRIPTIVE NOTE: LETTER REPORT

ABSTRACT: THE G-CAPSULE IS A DEVICE FOR TESTING THEORIES OF PROTECTION OF SUBJECTS AGAINST ACCELERATION. +9 GZ HAS BEEN ATTAINED WITHOUT CONTRAINDICATIONS.

ACCESSION NUMBER: 7735

SOURCE NAME: USAF HEADQUARTERS AIR MATERIEL COMMAND, ENGINEERING DIVISION

TITLE: A PRONE POSITION BED FOR PILOTS

PERSONAL AUTHORS: HERTZBERG, H.T.E., AND COLGAN, J.W.

REPORT DATE: 48/06/25

PAGINATION: 32P

REPORT SERIES NUMBER: MCREXD-695-71 D

ACCESSION NUMBER: NA

SOURCE: NORTH AMERICAN AIRCRAFT, ROCKWELL INTERNATIONAL CORP., P.O. BOX 92098, LOS ANGELES, CA 90009 (213)647-4231

TITLE: CENTRIFUGE TESTS OF A BODY SUPPORT DEVICE FOR PILOT ACCELERATION PROTECTION

PERSONAL AUTHORS: MONSON, C.B., ADAMS, W.J., FRAZIER, J.W., AND ALBERY, W.B.

REPORT DATE: 92

SUPPLEMENTARY NOTE: PAPER SUBMITTED TO SAFE JOURNAL ON 7/7/92.

DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: A BODY SUPPORT DEVICE (BSD) WAS DEVELOPED TO SUPPORT PILOTS IN A FORWARD-LEANING POSITION DURING EXPOSURE TO HIGH-GZ ACCELERATION. THE BSD IS DESIGNED TO PROVIDE HIGH LEVELS OF G-PROTECTION BY OFF-LOADING G-INDUCED FORCES FROM THE BODY AND TRANSFERRING THOSE FORCES TO THE PILOT'S EJECTION SEAT. BOTH TEST STAND STUDIES AT 1 G AND CENTRIFUGATION RUNS TO 9 G WERE CONDUCTED TO VALIDATE BSD CAPABILITIES. BSD STRAIN GAGE READINGS COLLECTED IN THE TEST STAND AND ON THE CENTRIFUGE USING ANTHROPOMETRIC MANIKINS AND HUMAN TEST SUBJECTS VALIDATED THE OFF-LOADING CAPABILITIES OF THE BSD. IN ADDITION, MEASUREMENTS OF HEART RATE, EKG, OXYGEN SATURATION, PERIPHERAL LIGHT LOSS AND COMFORT DEMONSTRATED THE EFFECTIVENESS OF THE BSD FOR COMFORTABLY SUPPORTING SUBJECTS ACCELERATED TO 9 G WITHOUT THE NEED FOR STRAINING OR OTHER PROTECTIVE MEASURES. (AUTHOR)

ACCESSION NUMBER: NA

SOURCE NAME: ROCKWELL INTERNATIONAL CORP., EL SEGUNDO, CA 92686

**TITLE:** A FORWARD-LEANING SUPPORT SYSTEM AND A BUOYANCY SUIT FOR PILOT ACCELERATION PROTECTION

**PERSONAL AUTHORS:** MONSON, C.B., AND ADAMS, W.J.

**REPORT DATE:** 91/11

**PAGINATION:** 7P

**SUPPLEMENTARY NOTE:** PRINTED IN SAFE 29TH ANNUAL SYMPOSIUM PROCEEDINGS

**ABSTRACT:** OVER THE PAST 7 YEARS, ROCKWELL HAS DEVELOPED TWO DEVICES FOR PILOT ACCELERATION PROTECTION; A BODY SUPPORT DEVICE (BSD) AND A BUOYANCE SUIT. THE BSD POSITIONS A PILOT IN A FORWARD-LEANING ORIENTATION WHEREAS THE BUOYANCY SUIT SURROUNDS A PILOT WITH WATER. TESTS HAVE SHOWN THAT SUBJECTS USING THE BSD OR WEARING A BUOYANCY SUIT HAVE A SIGNIFICANTLY HIGHER G TOLERANCE THAN SUBJECTS USING MORE CONVENTIONAL METHODS OF G PROTECTION. A CURRENT VERSION OF THE BSD HAS BEEN CENTRIFUGE TESTED WITH PROMISING RESULTS. CENTRIFUGE TESTS OF THE MOST RECENT BUOYANCE SUIT PROTOTYPE ARE PLANNED FOR 1992. (AUTHOR)

**ACCESSION NUMBER:** 91-123

**SOURCE NAME:** STEINKOPF, T. (PUBLISHER)

**TITLE:** MEDIZINISCHER LEITFADEN FUER FLIEGENDE BESATZUNGEN (MEDICAL MANUAL FOR FLYING PERSONNEL)

**PERSONAL AUTHORS:** VON DIRINGSHOFEN, H.

**REPORT DATE:** 39

**PAGINATION:** 100+

**SUPPLEMENTARY NOTE:** WORLD WAR II LUFTWAFFE MANUAL FOR PILOTS

**DIST/AVAIL STATEMENT:** POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS, MAY BE IN THE MACFARLAND COLLECTION AT THE FORDHAM HEALTH SCIENCE LIBRARY AT WRIGHT STATE UNIVERSITY, DAYTON, OH

**ABSTRACT:** ON PAGE 134, THE USE OF A CROUCH POSITION IS ILLUSTRATED FOR GERMAN PILOTS IN FIGHTER AND DIVE-BOMBER AIRCRAFT, PRIMARILY THE BR-109, AND THE FW-190 FIGHTER AIRCRAFT, AND THE JU-87 AND JU-88 DIVE-BOMBERS. THIS FORWARD CROUCH WAS USED IN CONJUNCTION WITH SHOUTING A LOUD "E-E-E-E-E" SOUND TO RAISE ABDOMINAL PRESSURE AND WAS QUITE EFFECTIVE IN RAISING +GZ TOLERANCE. IN GERMAN, THIS POSTURE IS CALLED THE ZUSAMMENGEKAUERTE SITZHALTUNG WHICH TRANSLATES APPROXIMATELY TO "THE ALL-TOGETHER SITTING-POSTURE." THIS DOCUMENT IS PROBABLY THE EARLIEST IN WHICH THE USE OF A CROUCHING POSTURE IS DOCUMENTED IN CONJUNCTION WITH A TYPE OF ANTI-G STRAINING MANEUVER AS A MODALITY FOR ACCELERATION TOLERANCE ENHANCEMENT OF AIRCREW.

**ACCESSION NUMBER:** NA

**SOURCE NAME:** AVIAT. SPACE AND ENVIR. MED., VOL. 63, NO. 5., MAY 1992, PG 398.

**TITLE:** PHYSIOLOGICAL COMPARISONS BETWEEN SUBJECTS IN THE FORWARD LEANING AND UPRIGHT POSTURES DURING HIGH GZ CENTRIFUGE TESTS

PERSONAL AUTHORS: WEI, L., FRAZIER, J.W., AND MONSON, C.B.

REPORT DATE: 92/5

PAGINATION: 1P

SUPPLEMENTARY NOTE: ABSTRACT FROM ASMA 63RD ANNUAL SCIENTIFIC MEETING

ABSTRACT: THIS ABSTRACT COMPARES PHYSIOLOGICAL DATA COLLECTED ON SUBJECTS DURING A +5 TO 9 GZ PROFILE DURING FORWARD LEANING OR UPRIGHT POSTURE. DATA RECORDED INCLUDED ECG, SAO2, AND ENDURANCE TIME-AT-G. IT WAS SHOWN THAT SUBJECTS HAD AN INCREASED SACM ENDURANCE TIME AND LOWER HEART RATE IN THE FORWARD LEAN POSITION. THEY CONCLUDED THAT SUBJECTS USING FORWARD LEANING POSTURE HAD GREATER GZ TOLERANCE THAN WHEN IN THE FULL UPRIGHT POSTURE.

ACCESSION NUMBER: NA

SOURCE NAME: 8TH ANNUAL MEETING OF THE IUPS COMMISSION ON GRAVITATION PHYSIOLOGY PROCEEDINGS, TOKYO, JAPAN 1986. BELIEVED ALSO TO HAVE BEEN PUBLISHED IN: THE PHYSIOLOGIST, VOL. 30, NO. 1 SUPPLEMENT 1987

TITLE: DEVELOPMENT OF METHODS FOR PREVENTION OF ACCELERATION INDUCED BLACKOUT AND UNCONSCIOUSNESS IN WORLD WAR II FIGHTER PILOTS. LIMITATIONS: PRESENT AND FUTURE.

PERSONAL AUTHORS: WOOD, E.H.

REPORT DATE: 86

PAGINATION: 2

SUPPLEMENTARY NOTE: PRESENTED PAPER

DIST/AVAIL STATEMENT: FROM THE LISTED SOURCES OR FROM DR. WOOD AT THE MAYO CLINIC, ROCHESTER, MN

ABSTRACT: DETAILED REVIEW OF THE EARLY DEVELOPMENT OF ANTI-G SUITS/VALVES. INCLUDES DESCRIPTION OF THE PROGRESSIVE ARTERIAL OCCLUSION SUIT WHICH PROVIDED CLOSE TO 3G OF PROTECTION. ADDRESSES THE USE OF PRONE PILOT POSITION AS A MEANS OF ENHANCING PILOT TOLERANCE IN ADVANCED FIGHTER AIRCRAFT. 25 REFERENCES.

ACCESSION NUMBER: NA

SOURCE NAME: SAFE JOURNAL, VOLUME 18, NO. 3, FALL 1988

TITLE: MAXIMUM PROTECTION ANTI-G SUITS AND THEIR LIMITATIONS

PERSONAL AUTHORS: WOOD, E.H.

REPORT DATE: 88

PAGINATION: 10

SUPPLEMENTARY NOTE: JOURNAL ARTICLE

DIST/AVAIL STATEMENT: FROM SAFE ASSOCIATION

ABSTRACT: THIS PAPER IS A PORTION OF THE EFFORT FUNDED BY DARPA STRATEGIC TECHNOLOGY OFFICE UNDER CONTRACT 66001-87-C-0079 TO CAPTURE THE

LITERATURE OF EARLY G PROTECTION RESEARCH AND DEVELOPMENT. FULL COVERAGE ANTI-G SUITS WERE FOUND TO BE THE MOST EFFECTIVE BUT BRADYCARDIA AND CARDIAC ARRHYTHMIAS DURING SUSTAINED +6 TO +9GZ TESTING IN THE EARLY 1950'S WERE CONSIDERED HAZARDOUS. CONSIDERABLE ATTENTION IS DEVOTED TO THE PRONE PILOT POSITION IN THIS PAPER AND CONCERNS ABOUT VISION, UNNATURAL BODY POSITIONS, IMPACT ON AIRCRAFT DESIGN, AND QUESTIONABLE PILOT ACCEPTANCE PREVENTED MUCH FURTHER STUDY OF THE PRONE POSITION. THIS PAPER PRESENTS CONSIDERABLE ADVOCACY FOR RECONSIDERATION OF THE HORIZONTAL POSITION (PREFERABLY PRONE) AS A MUCH SAFER ALTERNATIVE TO HIGH G PROTECTION THAN OTHER MODALITIES. THE POSSIBILITY OF ANATOMIC DAMAGE TO SKELETAL, CARDIOVASCULAR, OR ANATOMICALLY FRAGILE PULMONARY SYSTEMS SHOULD NOT BE DISREGARDED DURING CURRENT (1990) PLANNED RESEARCH AT +9 TO +12GZ, INCLUDES 52 REFERENCES.

## HIGH ACCELERATION COCKPIT RESEARCH

### SEATS AND RESTRAINT SYSTEMS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The McDonnell Douglas Corp. paper (Accession No. 47624), specifically the report MDC A2440-2 as well as the other papers relating to this early HAC seat work should be reviewed for current relevance in the interest of not re-inventing the wheel. The editor was informed at the 1990 SAFE Assoc. meeting, by Mr. Stephen C. Merriman, Branch Chief-Design, Crew Systems and Human Factors at McDonnell Aircraft Company (MAC) that the video tapes made during the 1970's on the AL/WPAFB centrifuge while testing this seat are probably still available at MAC. Mr. Merriman should be contacted at (314)234-2776 and followed up on this issue.

The issue of headrest geometry has been a troublesome one throughout the HAC seat development history. Contradictory opinions are represented by the paper by Burns and Whinnery versus the subsequent listed paper by Oldfield, et alia. In the final analysis the decision on the use and configuration of headrests is going to have to take into account operational requirements, body mobility, and cockpit control and display layouts. The issue of rapid seat articulation will enter into this decision process and, though some materials on this issue are repeated in this section, it is addressed in the section on spatial disorientation.

The impact of multi-axial motion environments was remarkably forecasted by the McDonald paper (Accession No. 3975) and points up the importance of the kinds of body, head/neck restraint issues that future fighter aircraft may impose. These are discussed in the Felder paper on microballoons (Accession No. 7818) and in the Hubbard paper on head and neck restraints. It should be recalled that the AL/CFBS experience with microballoons has not been a positive one. The materials are messy to deal with and, at least in the prototype tested in the so-called restraint and mobility test fixture, the cushion assemblies frequently leak. Also a contender in this area is the concept of a (pilot) motion activated articulating seat reported in 1991 by Skowronski, et al which is an interesting application of present day technology with ramifications for pilot loss of consciousness monitoring systems.

Finally, it should be noted that the ever-present controversy over how much back angle is sufficient is pointed up in the Glaister paper (Accession No. 45117) which should be reviewed prior to commencing an experimental design. Recommend that any future AL/CFBS program be closely coordinated with what is apparently a high level Navy program. Refer to the Zenobi paper, below, and the 1990 SAFE Assoc. briefing on the Navy program.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 48787  
SOURCE NAME: U.S. NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA

**TITLE:** DEVELOPMENT OF SUPINE SEAT AND RELATED COMPONENTS  
**REPORT DATE:** 55/11/30  
**PAGINATION:** 7P  
**REPORT SERIES NUMBER:** NADC-MA-3-13169  
**DESCRIPTIVE NOTE:** LETTER REPORT

**ABSTRACT:** WITH 65 DEGREES SUPINATION, STRAINING AND A Z-2 ANTIBLACKOUT SUIT, THE TOLERANCE FOR 100% OF THE PILOTS TESTED (REGARDLESS OF UNPROTECTED G TOLERANCE) CAN BE RAISED TO ACCELERATION STRESS CONDITIONS UP TO +7 GZ FOR 30 SECONDS.

**ACCESSION NUMBER:** 47624  
**SOURCE NAME:** MCDONNELL AIRCRAFT COMPANY, ST LOUIS, MISSOURI

**TITLE:** HIGH ACCELERATION COCKPIT, VARIABLE SEAT/CONTROL

**REPORT DATE:** 73/11/01  
**PAGINATION:** 46P  
**REPORT SERIES NUMBER:** MDC A2440-2  
**DESCRIPTIVE NOTE:** SECOND QUARTERLY CONTRACT STATUS REPORT

**ABSTRACT:** THE OBJECTIVE OF THIS PROGRAM IS TO DEVELOP AN ARTICULATING HIGH G SEAT/FLIGHT CONTROL ASSEMBLY APPROPRIATE IN DESIGN FOR FIGHTER AIRCRAFT CAPABLE OF SUSTAINING COMBAT LOAD FACTORS UP TO AND INCLUDING +10 GZ. VARIABLE SEAT/CONTROL DEVELOPMENT INCLUDES FABRICATION OF EXPERIMENTAL HARDWARE, THROUGH THE EVOLUTIONARY DESIGN AID PROCESS, TESTING AND EVALUATION OF SEAT/CONTROLLER OPERATION AND PERFORMANCE IN A SIMULATED COMBAT ENVIRONMENT (FIXED BASE INTERACTIVE MANNED AIR COMBAT SIMULATION-MACS), AND DELIVERY OF THE TEST HARDWARE (RESULTING DESIGN AID VARIABLE SEAT/CONTROL ASSEMBLY) TO THE AIR FORCE FOR SUBSEQUENT TESTING IN THE AMRL DYNAMIC ENVIRONMENT SIMULATOR (DES).

**ACCESSION NUMBER:** 46783  
**SOURCE NAME:** AIR FORCE FLIGHT DYNAMICS LABORATORY,  
WRIGHT-PATTERSON AFB, OH

**TITLE:** INVESTIGATION OF FIGHTER AIRCRAFT ACCELERATION ENVIRONMENT AND A PILOT POSITIONING CONCEPT

**REPORT DATE:** 74/11  
**PAGINATION:** 34P  
**REPORT SERIES NUMBER:** AFFDL-TM-74-210-FER  
**DIST/AVAIL STATEMENT:** DISTRIBUTION LIMITED TO U.S. GOVERNMENT AGENCIES;  
TEST AND EVALUATION APPLIED NOVEMBER 1974. OTHERS  
SEND REQUESTS TO: WL/FIER, WRIGHT-PATTERSON AFB, OH  
45433

**ABSTRACT:** THIS REPORT DESCRIBES THE EXPECTED ACCELERATION ENVIRONMENT OF THE NEXT GENERATION OF FIGHTER AIRCRAFT UTILIZING CONTROL CONFIGURED VEHICLE (CCV) TECHNOLOGY. THE MAXIMUM ACCELERATION ENVIRONMENT IS DEFINED IN TERMS OF THE MAGNITUDE, RATE-OF-ONSET, AND DIRECTION OF THE ACCELERATION COMPONENTS EXPERIENCED BY THE PILOT IN COMBAT MANEUVERING. A



NEW CONCEPT, CALLED AN INFLATABLE SEAT CUSHION, FOR PROVIDING A HIGH ACCELERATION COCKPIT (HAC) POSITIONING SYSTEM (65 DEGREE BACK ANGLE) WITH A CONVENTIONAL EJECTION SEAT IS ALSO DESCRIBED. THE IMPACT OF CCV AND HAC AIRCRAFT ON CREW STATION DESIGN IS DISCUSSED.

ACCESSION NUMBER: 48741  
SOURCE NAME: BRITISH AIRCRAFT CORP., WARTON, ENGLAND

TITLE: THE DESIGN OF A HIGH G COCKPIT

PERSONAL AUTHORS: BARNES, A.G.

REPORT DATE: 78/06  
PAGINATION: 12P  
REPORT SERIES NUMBER: AGARD  
DIST/AVAIL STATEMENT: PUB. IN AGARD FIGHTER AIRCRAFT DESIGN

ABSTRACT: THE PHYSIOLOGICAL FACTORS OF OPERATING UNDER HIGH G ARE DISCUSSED. THE GEOMETRIC ASPECTS OF RECLINING THE PILOT'S SEAT, IN ORDER TO ACHIEVE A MEASURE OF G ALLEVIATION, ARE ILLUSTRATED. THE IMPLICATIONS OF SUCH A CHANGE WITH RESPECT TO DISPLAYS AND CONTROLS ARE CONSIDERED ALONG WITH TECHNIQUES WHICH OFFER SOLUTIONS TO THE PROBLEMS ASSOCIATED WITH DISPLAYS AND CONTROLS. RADICAL CHANGES IN COCKPIT LAYOUT ARE IMPLIED.

ACCESSION NUMBER: 45119  
AD: A  
AD NUMBER: 103663  
SOURCE NAME: AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE,  
NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

TITLE: THE DEVELOPMENT AND AIRBORNE TESTING OF THE PALE SEAT

PERSONAL AUTHORS: VON BECKH, H.J.

REPORT DATE: 81/06/20  
PAGINATION: 90P  
REPORT SERIES NUMBER: NADC-81200-60

ABSTRACT: THE URGENCY TO PROVIDE FIGHTER AIRCRAFT WITH TRANSVERSE POSITIONED SEATS CAN NOT BE OVER-EMPHASIZED AT THIS TIME. A SQUADRON OF AIRCRAFT EQUIPPED WITH THESE SEATS WOULD HAVE A SPECTACULAR ADVANTAGE IN AIR COMBAT SITUATIONS, AND COULD LITERALLY FLY CIRCLES AROUND THE ADVERSARY AIRCRAFT.

ACCESSION NUMBER: 45118  
AD NUMBER: 756630  
SOURCE NAME: CREW SYSTEMS DEPT., NAVAL AIR DEVELOPMENT CENTER,  
WARMINSTER, PA

TITLE: G PROTECTIVE AIRCRAFT SEATS, WITH SPECIAL  
CONSIDERATION GIVEN TO PELVIS AND LEGS ELEVATING  
(PALE) SEATS

PERSONAL AUTHORS: VON BECKH, H.J.  
REPORT DATE: 72/10/02  
PAGINATION: 50P  
REPORT SERIES NUMBER: NADC-72262-CS

ABSTRACT: THE AUTHOR IS DEVELOPING A CREW SEAT WHICH ACHIEVES THE SUPINE POSITION, NOT BY RECLINING THE SEAT-BACK, BUT BY ELEVATING THE PELVIS AND LEGS FORWARDS-UPWARDS, WHILE THE HEAD AND THE SHOULDERS BARELY MOVE. IN ORDER TO DIFFERENTIATE THIS TYPE OF SUPINATING SEAT FROM RECLINING SEATS, IT IS NAMED PALE (PELVIS AND LEGS ELEVATING SEAT).

ACCESSION NUMBER: 8221  
AD NUMBER: 741202  
SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

TITLE: G PROTECTIVE TILTING AIRCRAFT SEATS

PERSONAL AUTHORS: VON BECKH, H.J.

REPORT DATE: 72/03/15  
PAGINATION: 56P  
DESCRIPTIVE NOTE: INTERIM REPORT

ABSTRACT: SEVERAL TILTING, SUPINATING SEATS WHICH HAVE BEEN TESTED IN FLIGHT AND ON CENTRIFUGES ARE DESCRIBED AND THEIR BIOMEDICAL ADEQUACY ASSESSED. ONLY THOSE, WHICH ASSURE UNRESTRICTED VISIBILITY IN ALL DIRECTIONS WILL BE ACCEPTED BY THE PILOTS. THIS CAN BE ACHIEVED BY AN ADEQUATE SELECTION OF THE PIVOT POINTS, AND OTHER DESIGN CRITERIA WHICH ARE SYNTHESIZED. CONCERTED EFFORT OF DESIGNERS, AEROMEDICAL INVESTIGATORS AND - LAST BUT NOT LEAST - PILOTS IS URGED FOR THE REALIZATION OF SUCH AN INTEGRATED G PROTECTIVE MAN-MACHINE SYSTEM. SUPINATING SEATS SHOULD ALSO BE PROVIDED FOR THE CREW OF WINGED REENTRY VEHICLES (SPACE SHUTTLE). FOR THE PASSENGERS MULTI-DIRECTIONAL G PROTECTIVE SYSTEMS WITH ESCAPE CAPABILITIES SHOULD BE DEVELOPED.

ACCESSION NUMBER: NA  
SOURCE NAME: AVIAT SPACE ENVIRON MED 1984; 55(2):122-127

TITLE: SIGNIFICANCE OF HEADREST GEOMETRY IN +GZ PROTECTIVE SEATS

PERSONAL AUTHORS: BURNS, J.W., AND WHINNERY, J.E.

REPORT DATE: 84/02  
PAGINATION: 6P  
SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
DIST/AVAIL STATEMENT: FROM SOURCE

ABSTRACT: THE EYE-HEART DISTANCE WAS MEASURED IN PATIENTS WITH MITRAL VALVE PROSTHESES IN ORDER TO OBTAIN DATA ON ANATOMICAL LANDMARKS TO BE USED FOR THE ESTIMATION OF THE MITRAL VALVE IN NORMAL SUBJECTS. TOLERANCE IN THREE DIFFERENT SEAT CONFIGURATIONS WAS MEASURED WITH NORMAL SS. SEATS WERE DESIGNATED AS THE "KENNEDY" DESIGN, THE USAFSAM DESIGN, AND ONE WITH A VERY

ERECT HEAD POSITION. CONCLUDES THAT AN ERECT HEAD POSITION IN A RECLINED SEAT COMPROMISES THE DEGREE OF PROTECTION AFFORDED BY SUPINATION SINCE THIS POSTURE INCREASES THE EYE-HEART DISTANCE.

ACCESSION NUMBER: 10639  
SOURCE NAME: FLIGHT CREW/AIRCRAFT DIVISION, NORTHROP CORPORATION,  
CALIFORNIA 90250  
  
TITLE: SEARCH FOR INFORMATION ON PRONE SEATING FOR FIGHTER  
COCKPITS  
  
PERSONAL AUTHORS: CARTER, V.E.  
  
REPORT DATE: 77/12/20  
PAGINATION: 12P  
REPORT SERIES NUMBER: 3894-82-77-70  
DESCRIPTIVE NOTE: MEMORANDUM

ACCESSION NUMBER: 7818  
SOURCE NAME: NORTHROP SPACE LABORATORIES, HAWTHORNE, CA  
  
TITLE: MICROBALLOON SUPPORT-RESTRAINT TECHNOLOGY REVIEW  
  
PERSONAL AUTHORS: FELDER, J.W., LOMBARD, C.F., AND POTTER, G.L.  
  
REPORT DATE: 66/06  
PAGINATION: 27P

ABSTRACT: A VARIETY OF SMALL HOLLOW SPHERES (MICROBALLOONS) WERE  
TESTED RESULTING IN THE SELECTION OF EPOXY SPHERES AS THE MOST PROMISING FOR  
USE IN THE PADDING OF A SUPPORT-RESTRAINT SYSTEM. PADDING SYSTEMS USING  
MICROBALLOONS HAVE BEEN EVALUATED IN ANIMAL AND HUMAN TESTS AND HAVE  
DEMONSTRATED THE FEASIBILITY OF THE "MICROBALLOON PRINCIPLE" IN PROVIDING  
SELF-CONTOURING PADDING IN SUPPORT-RESTRAINT SYSTEMS, FUNCTIONING TO PROVIDE  
BOTH COMFORT DURING NORMAL USE AND PROTECTION DURING HIGH +GZ LOADING.

ACCESSION NUMBER: 3217  
AD NUMBER: 133233  
SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA, AVIATION  
MEDICAL ACCELERATION LAB

TITLE: MODIFICATION OF F7F, INSTALLATION OF SUPINE SEAT AND  
RELATED COMPONENTS, INFLIGHT EVALUATION OF THE SEAT

PERSONAL AUTHORS: GELL, C.F.  
  
REPORT DATE: 51/09/12  
PAGINATION: 1 VOLUME  
REPORT SERIES NUMBER: NADC-MA-L5104

ACCESSION NUMBER: 3216  
AD NUMBER: 133234

**SOURCE NAME:** NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA, AVIATION MEDICAL ACCELERATION LAB

**TITLE:** MODIFICATION OF F7F, INSTALLATION OF SUPINE SEAT AND RELATED COMPONENTS - INFLIGHT EVALUATION OF THE SEAT

**PERSONAL AUTHORS:** GELL, C.F.

**REPORT DATE:** 52/12/10

**PAGINATION:** 1 VOLUME

**REPORT SERIES NUMBER:** NADC-MA-L5208

**ACCESSION NUMBER:** 45117

**AD:** B

**AD NUMBER:** 034785

**SOURCE NAME:** FLYING PERSONNEL RESEARCH COMMITTEE, RAAF INSTITUTE OF AVIATION MEDICINE, FARNBOROUGH, HANTS, ENGLAND

**TITLE:** THE INFLUENCE OF SEAT BACK ANGLE ON ACCELERATION TOLERANCE

**PERSONAL AUTHORS:** GLAISTER, D.H.

**REPORT DATE:** 78/03/11

**PAGINATION:** 20P

**REPORT SERIES NUMBER:** FPRC-1365

**ABSTRACT:** BEST FIT REGRESSIONS PREDICTED THAT IN ORDER TO INCREASE GREYOUT TOLERANCE BY 1 GZ FROM THAT OBTAINED IN A CONVENTIONAL UPRIGHT SEAT, A BACK ANGLE OF 58 DEG WOULD BE REQUIRED, WHILST INCREMENTS OF 2 AND 3 GZ WOULD REQUIRE ANGLES OF 69 AND 74 DEG RESPECTIVELY. AN ANTI-G SUIT WAS FOUND TO GIVE AN INCREASE IN GREYOUT TOLERANCE OF +1.21 GZ AND FULL PROTECTION +3.15 GZ INDEPENDENT OF BACK ANGLE.

**ACCESSION NUMBER:** 90-19

**SOURCE NAME:** PROCEEDINGS OF THE 27TH ANNUAL SAFE SYMPOSIUM, SAFE ASSOCIATION.

**TITLE:** CRASH VICTIM MODELING OF A NEW HEAD AND NECK SUPPORT

**PERSONAL AUTHORS:** HUBBARD, R.P., AND BEGEMAN, P.C.

**REPORT DATE:** 89/12

**PAGINATION:** 5P

**SUPPLEMENTARY NOTE:** PRESENTED PAPER

**DIST/AVAIL STATEMENT:** SAFE ASSOCIATION

**ABSTRACT:** DESCRIBES A SYSTEM OF HARNESS MOUNTED TETHERS WHICH LIMIT HEAD AND NECK MOTION. FIRST REPORTED BY HUBBARD AT THE 1987 SAFE SYMPOSIUM AND ON WHICH THERE IS A U.S. PATENT. APPLICATIONS IN VEHICLES, MOTOR RACING, AND POSSIBLY IN PRESENT AND FUTURE HAC OR SUPERMANEUVERABILITY FIGHTER AIRCRAFT. THIS PAPER REPORTS THE RESULTS OF A CAL-3D (CALSPAN 3-

DIMENSIONAL CRASH VICTIM SIMULATION PROGRAM) STUDY INVOLVING RUNS WITH AND WITHOUT THE SIMULATED HEAD AND NECK SUPPORT SYSTEM (HANS) IN 30 AND 35 MPH BARRIER EQUIVALENT VELOCITY (BEV) IMPACTS.

ACCESSION NUMBER: 8110  
SOURCE NAME: US ARMY AEROMEDICAL RESEARCH LABORATORY, FORT RUCKER, AL  
  
TITLE: NECK MUSCLE STRESS INDUCED BY POSTURAL EFFECTS AND VIBRATION OF A SUPINE SEAT  
  
PERSONAL AUTHORS: JOHNSON, J.C., AND WELLS, J.H.  
  
REPORT DATE: 81/05  
PAGINATION: 2P  
SUPPLEMENTARY NOTE: AEROSPACE MEDICAL ASSOCIATION ANNUAL SCIENTIFIC MEETING, MAY 4-7 1981, CONVENTION CENTER, SAN ANTONIO TX  
  
DIST/AVAIL STATEMENT: PREPRINTS OF 1981 ANNUAL SCIENTIFIC MEETING, AEROSPACE MEDICAL ASSOCIATION, 1981, P 209-210

ACCESSION NUMBER: NA  
DTIC AD NUMBER: ATI (AIR TECHNICAL INTELLIGENCE-A DESIGNATION NOW OBSOLETE) 79310  
SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL  
  
TITLE: A DEVICE FOR THE AUTOMATIC CONTROL BY G FORCE OF THE POSITION OF THE CONTROLLABLE SUPINE SEAT  
  
PERSONAL AUTHORS: KELLY, R.E., AND STAUFFER, F.R.  
  
REPORT DATE: 50/03  
REPORT SERIES NUMBER: PROJECT NM 001 059.02.05  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

ABSTRACT: DESCRIBES AN AUTOMATICALLY SUPINATING SEAT. VERY GOOD INFORMATION ON SEAT MOTION. ALTERING THE SEAT BACK ANGLE OVER THE AVAILABLE RANGE OF MOTION UNDER UP TO +5Gz WAS WELL TOLERATED OVER A 2 SEC. PERIOD OF TIME. POTENTIAL IMPLICATIONS FOR CONCERNS ABOUT PILOT ANGULAR MOTION IN THE X-Z AXES IN SUPERMANEUVERABILITY MANEUVERS AND TACTICS.

ACCESSION NUMBER: 48736  
AD: D  
AD NUMBER: 011510  
SOURCE NAME: DEPT OF THE AIR FORCE, WASHINGTON, DC  
  
TITLE: TRANSLATING RUDDER PEDAL SYSTEM  
  
PERSONAL AUTHORS: LARSON, G.W., LEE, W.E., AND LEWIS, E.N., JR  
REPORT DATE: 84/11

PAGINATION: 6P  
REPORT SERIES NUMBER: US PATENT 4,484,722  
SUPPLEMENTARY NOTE: N85-21172  
DESCRIPTIVE NOTE: PATENT

ABSTRACT: A TRANSLATING RUDDER PEDAL SYSTEM WHICH INCLUDES A RUDDER PEDAL ASSEMBLY AND A RECLINABLE, TRANSLATIONALLY MOVEABLE, SEAT OPERABLY CONNECTED TO THE PEDAL ASSEMBLY, WITH BOTH THE PEDAL ASSEMBLY AND THE SEAT MOUNTED IN A VEHICLE, SUCH AS AN AIRCRAFT IS DESCRIBED. THE SYSTEM ENSURES THAT, IRRESPECTIVE OF THE MOVEMENT AND POSITIONING OF THE SEAT, THE FEET OF THE USER SEATED IN THE SEAT ALWAYS REMAINS IN CONTACT WITH THE CONTROL PEDALS OF THE RUDDER PEDAL ASSEMBLY.

ACCESSION NUMBER: 3975  
AD: A  
AD NUMBER: 076061  
SOURCE NAME: DOUGLAS AIRCRAFT CO., LONG BEACH, CA

TITLE: ADVANCED DESIGN AIRCREW PROTECTIVE RESTRAINT SYSTEMS.

PERSONAL AUTHORS: MCDONALD, A.B.

REPORT DATE: 79/08  
PAGINATION: 59P  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-79-45

ABSTRACT: THIS STUDY IS THE INITIAL PHASE OF A PROGRAM AIMED AT THE DEVELOPMENT OF ADVANCED DESIGN AIRCREW SYSTEMS FOR THE NEXT GENERATION OF AIR FORCE COMBAT AIRCRAFT. FOR THESE NEW AIRCRAFT, IT IS ANTICIPATED THAT COMBAT OPERATIONS WILL INVOLVE HIGH MULTIAXIAL ACCELERATION MANEUVERS AND THAT NEW AIRCREW SYSTEMS WILL BE REQUIRED FOR RESTRAINT, PROTECTION AND ESCAPE UNDER THESE COMBAT CONDITIONS.

ACCESSION NUMBER: 7961  
AD: A  
AD NUMBER: 108274  
SOURCE NAME: DOUGLAS AIRCRAFT CO., LONG BEACH, CA

TITLE: AIRCREW RESTRAINT AND MOBILITY TEST FIXTURE

PERSONAL AUTHORS: MCDONALD, A.B.

REPORT DATE: 81/07  
PAGINATION: 33P  
MONITOR ACRONYM: AFAMRL  
MONITOR SERIES: AFAMRL-TR-81-27

ABSTRACT: THE NEXT GENERATION COMBAT AIRCRAFT WITH ADVANCED AERODYNAMIC AND CONTROL FEATURES WILL HAVE COMBAT MANEUVER CAPABILITY WHICH WILL IMPOSE MULTIAXIAL ACCELERATIONS ON THE AIRCREW. ADVANCED AIRCREW SYSTEMS WILL BE REQUIRED FOR RESTRAINT, SUPPORT, AND MOBILITY DURING THESE COMBAT

CONDITIONS. NEW CONCEPTS FOR THESE SYSTEMS HAVE BEEN DEFINED, BUT TESTS UNDER REPRESENTATIVE DYNAMIC CONDITIONS ARE NECESSARY TO EVALUATE THE EFFECTIVENESS OF THESE CONCEPTS WHEN IMPLEMENTED.

ACCESSION NUMBER: 7930  
AD: B  
AD NUMBER: 027687  
SOURCE NAME: ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH, ENGLAND  
  
TITLE: AN INVESTIGATION INTO POSSIBLE BACK PROFILES FOR RECLINED SEATS IN AIR-TO-AIR COMBAT AIRCRAFT  
  
PERSONAL AUTHORS: OLDFIELD, D.E., PORT, W.G., AND CHISMAN, S.W.  
  
REPORT DATE: 78/01  
PAGINATION: 26P  
REPORT SERIES NUMBER: RAE-TR-78013  
MONITOR ACRONYM: DRIC  
MONITOR SERIES: DRIC-BR-61570  
DIST/AVAIL STATEMENT: DISTRIBUTION: DOD AND DOD CONTRACTORS ONLY: OTHERS TO BRITISH MINISTRY OF DEFENCE VIA THE APPROPRIATE CHANNEL

ABSTRACT: CURRENT INTEREST IN AIR-TO-AIR COMBAT HAS GENERATED INCREASED CONSIDERATION OF THE USE OF A RECLINED SEAT AS A MEANS OF IMPROVING THE PILOT'S CAPABILITY TO WITHSTAND HIGH G. HOWEVER, IT HAS RECENTLY BEEN SUGGESTED THAT IT MIGHT NOT BE REASONABLE TO DESIGN A SEAT IN WHICH THE PILOT NEEDED TO REST HIS HEAD ON A HEADREST FOR PROLONGED PERIODS DURING NORMAL FLYING. THIS REPORT COVERS WORK ON THE PROFILE OF A RECLINED SEAT AND AN ESTIMATE OF THE PROBABLE IMPROVEMENT IN RELAXED GREY-OUT THRESHOLD TO BE EXPECTED IF THE SEAT WERE DESIGNED SO THAT THE PILOT WAS ABLE TO HOLD HIS HEAD IN A COMFORTABLE UPRIGHT POSITION WITHOUT USING A HEADREST. IT WAS SHOWN THAT A RECLINED SEAT DESIGNED IN THIS WAY GAVE ONLY MINOR IMPROVEMENT IN RELAXED GREY-OUT THRESHOLD COMPARED WITH A CONVENTIONAL UPRIGHT SEAT, AND THE IMPROVEMENT WAS SIGNIFICANTLY LESS THAN HAD BEEN FOUND WITH SEATS IN WHICH THE PILOT NEEDED TO PLACE HIS HEAD ON A HEADREST. THESE RESULTS POINT CLEARLY TO THE NEED FOR SERIOUS CONSIDERATION TO BE GIVEN TO THE HEADREST ASPECT OF RECLINED SEAT DESIGN.

ACCESSION NUMBER: 48737  
SOURCE NAME: GOODYEAR AEROSPACE CORP., AKRON, OH  
  
TITLE: INFLATABLE SEAT CUSHION SYSTEM FOR HIGH ACCELERATION COCKPIT  
  
PERSONAL AUTHORS: ROBERTS, E.O., AND GIRARD, L.A., JR  
  
REPORT DATE: 75/09/21  
PAGINATION: 9P  
DIST/AVAIL STATEMENT: PUB. IN PROCEEDINGS, SAFE ASSOCIATION, PP 5-13, 1975  
SUPPLEMENTARY NOTE: PRESENTED AT 13TH ANNUAL CONFERENCE AND TRADE EXHIBIT, SAFE, SAN ANTONIO, TX, 21-26 SEPTEMBER 1975

**ABSTRACT:** THIS PAPER DISCUSSES THE DETAILED DESIGN AND STRUCTURAL ANALYSIS OF A CURRENT PROGRAM TO DEVELOP AN INFLATABLE SEAT CUSHION SYSTEM FOR THE HIGH ACCELERATION COCKPIT. THIS SYSTEM, WHICH IS INTEGRATED WITH AN EXISTING EJECTION SEAT, CONSISTS OF AN INFLATABLE SEAT CUSHION INSERT PLUS A NORMAL INFLATION/DEFLATION SYSTEM, AN EMERGENCY DEFLATION SYSTEM, AND A PILOT RESTRAINT ASSEMBLY. THE OBJECTIVE OF THIS CURRENT PROGRAM IS TO DEMONSTRATE THAT THE INFLATABLE SEAT CUSHION CAN, UPON SELECTION, RECLINE THE AIRCREWMAN FROM HIS NORMAL POSITION OF 15.5 DEGREES BACK ANGLE TO A SEMISUPINE POSITION OF 65 DEGREES BACK ANGLE IN 2 TO 5 SECONDS AND THEN, UPON SELECTION, RETURN THE AIRCREWMAN TO HIS NORMAL POSITION OF 15.5 DEGREES BACK ANGLE IN 2 TO 5 SECONDS. IN ADDITION, AN EMERGENCY DEFLATE SYSTEM IS TO BE INCORPORATED INTO THE INFLATABLE SEAT CUSHION THAT WILL BE CAPABLE OF REPOSITIONING THE AIRCREWMAN FROM THE SEMI-SUPINE POSITION TO HIS NORMAL POSITION IN 0.3 SECONDS OR LESS SO THAT HE CAN BE EJECTED FROM THE AIRCRAFT.

**ACCESSION NUMBER:** 48742  
**SOURCE NAME:** BRITISH AEROSPACE, KINGSTON-UPON-THAMES, SURREY, ENGLAND  
**TITLE:** THE DESIGN OF FUTURE COCKPITS FOR HIGH PERFORMANCE FIGHTER AIRCRAFT  
**PERSONAL AUTHORS:** ROE, G.  
**REPORT DATE:** 78/04  
**PAGINATION:** 8P  
**DIST/AVAIL STATEMENT:** PUB. IN AERONAUTICAL JOURNAL 82:159-166 APRIL 1978

**ABSTRACT:** MEANS OF INCREASING A PILOT'S G-TOLERANCE THROUGH INCREASING THE RECLINE ANGLE OF THE SEAT ARE DISCUSSED, AND THE CORRESPONDING MODIFICATIONS REQUIRED IN COCKPIT DISPLAYS AND EJECTOR DESIGN ARE CONSIDERED. IN PARTICULAR, AN ARTICULATED SEAT PROVIDING THE ADDITIONAL RECLINE ANGLE TO GIVE A TOLERANCE INCREASE OF ABOUT 2 G MAGNITUDE OVER PRESENT LEVELS IS PROPOSED. OPTIMUM LOCATIONS FOR FLIGHT, SENSOR AND SYSTEMS DATA DISPLAYS ARE DETERMINED ON THE BASIS OF INFORMATION REQUIREMENTS FOR THE PILOT DURING TAKEOFF, CLIMB, CRUISE AND OTHER MANEUVERS. A HEAD-UP DISPLAY FOR FLIGHT INFORMATION AND A HEAD-LEVEL DISPLAY FOR SENSOR DATA ARE SUGGESTED.

**ACCESSION NUMBER:** NA  
**SOURCE NAME:** COMPENDIUM OF AVIATION MEDICINE, BERLIN, MAY 1939  
**TITLE:** TITLE UNKNOWN  
**PERSONAL AUTHORS:** RUFF, S.  
**REPORT DATE:** 39/05/00  
**SUPPLEMENTARY NOTE:** JOURNAL ARTICLE  
**DIST/AVAIL STATEMENT:** POSSIBLY AVAILABLE THROUGH THE LIBRARY OF CONGRESS

**ABSTRACT:** DESCRIBES THE DEVELOPMENT OF THE "KIPP SITZ", OR FLOP-BACK SEAT. THIS SEAT WAS INTENDED TO BE USED IN LUFTWAFFE DIVE-BOMBERS (PRIMARILY THE JU-87 STUKA) AND HAD A SPRING-LOADED SEAT BACK THAT COLLAPSED



TO A SUPINE POSITION WHEN THE AIRFRAME ACCELERATION REACHED +3Gz. WHEN THE LOAD FACTOR DECREASED BELOW THAT LEVEL, THE SEAT BACK WAS ERECTED BY THE SAME SPRINGS. NEVER USED OPERATIONALLY.

ACCESSION NUMBER: 7796  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST LOUIS, MO  
TITLE: HIGH ACCELERATION COCKPIT: VARIABLE SEAT/CONTROL  
PERSONAL AUTHORS: SINNETT, J.M., ASIALA, C.F., AND PROUHET, E.P.  
REPORT DATE: 73/08/01  
PAGINATION: 18P  
REPORT SERIES NUMBER: MDC-A2440-1  
MONITOR ACRONYM: AMRL  
SUPPLEMENTARY NOTE: FOR FINAL TECHNICAL REPT. SEE ACCESSION NO. 3754, ADC-001827  
DESCRIPTIVE NOTE: FIRST QUARTERLY REPT. 1 MAY-1 AUG 73

ABSTRACT: THE OBJECTIVE OF THIS PROGRAM IS TO DEVELOP AN ARTICULATING HIGH G SEAT/FLIGHT CONTROL ASSEMBLY APPROPRIATE IN DESIGN FOR FIGHTER AIRCRAFT CAPABLE OF SUSTAINING COMBAT LOAD FACTORS UP TO AND INCLUDING 10 GZ. VARIABLE SEAT/CONTROL DEVELOPMENT INCLUDES FABRICATION OF EXPERIMENTAL HARDWARE, THROUGH THE EVOLUTIONARY DESIGN AID PROCESS, TESTING AND EVALUATION OF SEAT/CONTROLLER OPERATION AND PERFORMANCE IN A SIMULATED COMBAT ENVIRONMENT (FIXED BASE INTERACTIVE MANNED AIR COMBAT SIMULATION - MACS), AND DELIVERY OF THE TEST HARDWARE (RESULTING DESIGN AID VARIABLE SEAT/CONTROL ASSEMBLY) TO THE AIR FORCE FOR SUBSEQUENT TESTING IN THE AMRL DYNAMIC ENVIRONMENT SIMULATOR (DES).

ACCESSION NUMBER: 3754  
AD: C  
AD NUMBER: 001827  
SOURCE NAME: MCDONNELL AIRCRAFT CO, ST LOUIS, MO  
TITLE: HIGH ACCELERATION COCKPIT VARIABLE SEAT/CONTROL ASSEMBLY.  
PERSONAL AUTHORS: SINNETT, J.M., ASIALA, C.F., AND PROUHET, E.P.  
REPORT DATE: 74/11  
PAGINATION: 222P  
REPORT SERIES NUMBER: MDC-A2441  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-74-114  
DIST/AVAIL STATEMENT: DISTRIBUTION LIMITED TO U.S. GOV'T. AGENCIES ONLY; TEST AND EVALUATION; 30 SEP 74. OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO AL/CFPP, ATTN: STINFO, WRIGHT-PATTERSON AFB, OHIO 45433

ACCESSION NUMBER: NA  
AD NUMBER: 76458

SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL

TITLE: CERTAIN PHYSIOLOGICAL RESPONSES IN MAN CHANGING FROM THE SITTING TO THE SUPINE POSITION DURING RADIAL ACCELERATORY FORCE

PERSONAL AUTHORS: STAUFFER, F.R.

REPORT DATE: 50/03

REPORT SERIES NUMBER: PROJECT NM 001 059.02.02

SUPPLEMENTARY NOTE: NAVY PROJECT REPORT

DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

ABSTRACT: REPORTS NO ADVERSE EFFECT ON PILOT VESTIBULAR SENSES WHEN RAPIDLY SUPINATING A G-CONTROLLABLE SEAT UNDER SUSTAINED ACCELERATION AT UP TO +5Gz. CONCLUDES THERE IS NO VESTIBULAR OR SPATIAL DISORIENTATION REASON NOT TO USE THIS SEAT CONCEPT OPERATIONALLY AS AN ACCELERATION PROTECTION METHOD. SEE ALSO A SIMILAR PAPER BY KELLY, R.E., AND STAUFFER, F.R. THIS INFORMATION ALSO HAS IMPLICATIONS FOR SUPERMANEUVERABILITY TACTICS AND MANEUVERS.

ACCESSION NUMBER: NA

SOURCE NAME: INTERAVIA, FEBRUARY 1987; 121-22

TITLE: G-LOC: NEW IDEAS BUT NO EASY CURES

PERSONAL AUTHORS: SWEETMAN, W.

REPORT DATE: 87/02

PAGINATION: 2

REPORT SERIES NUMBER: NA

SUPPLEMENTARY NOTE: JOURNAL ARTICLE

DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: REPORTS AND INTERVIEW WITH DR. R. E. VAN PATTEN AT THE ARMSTRONG LABORATORY, WRIGHT PATTERSON AFB, OH. TOPICS INCLUDE HIS RESEARCH ON THE RATE SENSITIVE AND FLIGHT CONTROL ACTIVATED ELECTRONIC ANTI-G VALVES, AND ON AN ARTIFICIAL INTELLIGENCE-BASED SYSTEM FOR THE DETECTION OF AND INTERVENTION IN G-INDUCED LOSS OF CONSCIOUSNESS. ALSO CONTAINS INFORMATION ON THE MARTIN-BAKER ARTICULATED EJECTION SEAT.

ACCESSION NUMBER: NA

SOURCE NAME: AEROSPACE MEDICINE VOL 33:279-85 MARCH 1962

TITLE: AN INTERCHANGEABLE, MOBILE, PILOT-RESTRAINT SYSTEM FOR USE IN HIGH SUSTAINED ACCELERATION FORCE FIELDS

PERSONAL AUTHORS: VYKUKAL, H.C., GALLANT, R.P., ET ALIA

REPORT DATE: 62/03

PAGINATION: 7

SUPPLEMENTARY NOTE: JOURNAL ARTICLE

**DIST/AVAIL STATEMENT:** SOURCE

**ABSTRACT:** NO ABSTRACT AVAILABLE WHEN ENTERED INTO THIS DATABASE

**ACCESSION NUMBER:** 8198  
**AD:** B  
**AD NUMBER:** 036611  
**SOURCE NAME:** NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

**TITLE:** FEASIBILITY OF RETROFITTING CURRENT NAVY AIRCRAFT  
COCKPITS TO ACHIEVE IMPROVED CREWMEMBER GZ TOLERANCE

**PERSONAL AUTHORS:** ZENOBI, T.J.

**REPORT DATE:** 79/03/27  
**PAGINATION:** 15P  
**REPORT SERIES NUMBER:** NADC-79017-60

**ABSTRACT:** EXTENSIVE COCKPIT MODIFICATION IN CURRENT HIGH PERFORMANCE NAVY AIRCRAFT IS REQUIRED TO PROTECT CREWMEMBERS FROM SUSTAINED ACCELERATION LOADS OF APPROXIMATELY 8 TO 10 GZ. CURRENTLY, MOST CREWMEMBERS CANNOT PERFORM ADEQUATELY AT LEVELS OF ABOUT 4 GZ AND GREATER. IMPROVEMENTS IN THE DESIGN OF ANTI-G SUITS/VALVES MAY INCREASE GZ TOLERANCE BY 1 OR 2 GZ AND REQUIRE NOMINAL MODIFICATION TO THE COCKPIT. INCORPORATION OF A SUPINATING SEAT REQUIRES INSTRUMENT PANEL, FLIGHT CONTROLS AND EJECTION SEAT MODIFICATION. BEFORE AN INTENSIVE EFFORT IS UNDERTAKEN TO ACHIEVE CREWMEMBER PROTECTION AGAINST SUSTAINED GZ EFFECTS, THE NAVY MUST FIRST BE SURE THAT THE BENEFITS WILL BE WORTH THE LARGE SUMS OF FUNDS WHICH WILL BE SPENT. A RE-EVALUATION OF THE NEED FOR A SUSTAINED G PROTECTION RETROFIT EFFORT IS RECOMMENDED.

**ACCESSION NUMBER:** NA  
**SOURCE NAME:** NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

**TITLE:** HIGH ACCELERATION SEATING: ADVANCED TECHNOLOGY CREW  
STATION

**PERSONAL AUTHORS:** ZENOBI, T.

**REPORT DATE:** 901200  
**PAGINATION:** 14  
**SUPPLEMENTARY NOTE:** HARDCOPIES OF VUGRAFS FROM ORAL PRESENTATION  
**DIST/AVAIL STATEMENT:** FROM AUTHOR AT SOURCE

**ABSTRACT:** INFIGHT CONCERNS ARE CREWMEMBER RESTRAINT, GZ-TOLERANCE, VISION, AND REACH. EMERGENCY ESCAPE CONCERNS ARE EJECTION SEATS, ESCAPE CAPSULES, AND ENCAPSULATED SEATS. CONFIGURATION OPTIONS BEING CONSIDERED INCLUDE THE PALE SEAT, UPPER TORSO RECLINE, FORWARD SUPINATION (PRONATION), AND STANDARD SEATING WITH GZ PROTECTION AIDES. CONCERNS IN MULTI-POSITION VS FIXED SEATING INCLUDE: WHAT BACKANGLE? WHEN WOULD SEAT HAVE TO BE IN THE GZ PROTECTIVE POSITION? POWER REQUIREMENT NECESSARY TO REPOSITION A SEAT THROUGH 40° OF SEATBACK ANGLE IN 0.3 SECONDS IS ESTIMATED TO BE 8 HORSEPOWER. NADC HAS CONCERNS REGARDING COMFORT AND PERFORMANCE WITH RESPECT TO HEADREST DESIGNS AND HEAD SUPPORT AS WELL AS RESTRAINTS. REGARDING

LAYOUT, THE MAJOR CONCERNS ARE IN-COCKPIT VISION, OUT-OF-COCKPIT VISION, SEATING POSTURE AND MOBILITY, HELMET MOUNTED EQUIPMENT, AND THE HIGH G ENVIRONMENT. NADC IS CONSIDERING A 45° SEATBACK ANGLE FOR EJECTION. EMERGENCY ESCAPE TRADE-OFFS INCLUDE CAPSULE VS EJECTION SEAT: COST, WEIGHT, COMPLEXITY, G-PROTECTION, REPOSITIONABLE SEATBACK ANGLE, EJECTION ANGLE AND POSITION, EJECTION/ESCAPE SYSTEM PERFORMANCE INCLUDING ISSUES OF WINDBLAST (PHYSIOLOGY AND HARDWARE), AERODYNAMIC STABILITY AND RECOVERY, AND AIRCRAFT ATTITUDE. BRIEFING CONCLUDES WITH EXTENSIVE SUMMARY OF PEACETIME AND COMBAT EJECTIONS/EJECTION ENVIRONMENTS (SPINS, ROLLING, TUMBLING, DISINTEGRATING, INVERTED). THIS INFORMATION WAS PREPARED FOR NADC BY BIOTECHNOLOGY, INC. FINAL SECTION OF THE BRIEFING ADDRESSES THE IMPACT OF STAND-OFF WEAPONS, ATTACK SCENARIOS, AND DOGFIGHT/ACM ENVIRONMENTS WITH RESPECT TO THE DRIVE TOWARD A HIGH ACCELERATION COCKPIT.

## HIGH ACCELERATION COCKPIT RESEARCH

### SPATIAL DISORIENTATION IN ARTICULATING HIGH ACCELERATION COCKPIT SEATS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The two papers by Stauffer and Kelly indicate that at moderate levels of acceleration (+5Gz) and for relatively slow seatback motion there were no disorienting effects encountered on the long radius Naval Air Development Center human centrifuge.

The vestibular effects resulting from the combination of high sustained G's attendant to curvilinear flight trajectories and seatback motion are obviously crucial to the operational use of an articulating seat. Furthermore, there is another concern associated with the possible flight maneuvers associated with the concept of Supermaneuverability.

To illustrate: one of the maneuvers planned for a Supermaneuverability aircraft would result when that aircraft was subjected to a stern attack. The defending pilot would be able to execute an abrupt pitch up maneuver of as much as  $90^{\circ}$ . This action would be followed by yaw motion around the velocity vector of the aircraft in order to obtain lock-on and launch for an off-boresight missile aimed at the attacking aircraft which, at that point, will have overshoot the defending aircraft and be ahead and to one side of it.

This kind of consideration offers an attractive opportunity for research which would combine a study of seatback articulation, aspects of Supermaneuverability, and spatial disorientation. A study of this type could be conducted utilizing the powered and controllable gimbals of the Dynamic Environment Simulator (DES) at Wright Patterson AFB, OH. The subject and seat would be mounted within the gondola so as to be facing the main arm axis of rotation. The main arm could then be set in motion and spun up to the required level of acceleration, which would be felt by the subject as a +Gx acceleration. Having attained the necessary plateau level, the gondola would then be vectored so as to convert this +Gx inertial force to a force in the +Gz physiological axis. The vestibular effects of this maneuver could be assayed by electronystagmogram and, possibly, by the instinctive inputs to a sidearm controller made by subjects who were experienced fighter pilots.

Subsequent yaw motion could be generated by then operating the fork shaft axis of the DES so as to rotate the subject around the physiological Z axis and to simulate yaw around the velocity vector.

An additional advantage of this approach is that it would not require the actual construction of an articulating seat in order to study various seatback angles and/or rates of articulation since both of these could be simulated by gondola roll axis motion.

# LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: NA  
DTIC AD NUMBER: ATI (AIR TECHNICAL INTELLIGENCE- A DESIGNATION NOW OBSOLETE) 79310  
SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL  
TITLE: A DEVICE FOR THE AUTOMATIC CONTROL BY G FORCE OF THE POSITION OF THE CONTROLLABLE SUPINE SEAT  
PERSONAL AUTHORS: KELLY, R.E., AND STAUFFER, F.R.  
REPORT DATE: 50/03  
REPORT SERIES NUMBER: PROJECT NM 001 059.02.05  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

ABSTRACT: DESCRIBES AN AUTOMATICALLY SUPINATING SEAT. VERY GOOD INFORMATION ON SEAT MOTION. ALTERING THE SEAT BACK ANGLE OVER THE AVAILABLE RANGE OF MOTION UNDER UP TO +5Gz WAS WELL TOLERATED OVER A 2 SEC. PERIOD OF TIME. POTENTIAL IMPLICATIONS FOR CONCERNS ABOUT PILOT ANGULAR MOTION IN THE X-Z AXES IN SUPERMANEUVERABILITY.

ACCESSION NUMBER: NA  
DTIC AD NUMBER: 76458  
SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL  
TITLE: CERTAIN PHYSIOLOGICAL RESPONSES IN MAN CHANGING FROM THE SITTING TO THE SUPINE POSITION DURING RADIAL ACCELERATORY FORCE  
PERSONAL AUTHORS: STAUFFER, F.R.  
REPORT DATE: 50/03  
REPORT SERIES NUMBER: PROJECT NM 001 059.02.02  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

ABSTRACT: REPORTS NO ADVERSE EFFECT ON PILOT VESTIBULAR SENSES WHEN RAPIDLY SUPINATING A G-CONTROLLABLE SEAT UNDER SUSTAINED ACCELERATION AT UP TO +5Gz. CONCLUDES THERE IS NO VESTIBULAR OR SPATIAL DISORIENTATION REASON NOT TO USE THIS SEAT CONCEPT OPERATIONALLY AS AN ACCELERATION PROTECTION METHOD. THIS ENTRY MAY BE A DUPLICATE OF THE ENTRY (ABOVE) BY KELLY, RE., AND STAUFFER, FR. THIS INFORMATION ALSO HAS IMPLICATIONS FOR SUPERMANEUVERABILITY TACTICS AND MANEUVERS.

## HIGH ACCELERATION COCKPIT RESEARCH

### TACTICS AND AIR COMBAT HIGH ACCELERATION COCKPITS ANALYSES AND SIMULATIONS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

The literature reviewed in this section should be approached with caution, specifically those studies performed prior to 1985. These studies are unlikely to take into account the advent of the Supermaneuverability concept, nor are they likely to be up-to-date with respect to the "all aspect" capabilities of the missiles which will be in operational use by, say, the year 2010 (it being unlikely that a true HAC aircraft would be flown much prior to that time).

Any planned research in the HAC area must first be coordinated with the airframe and armaments communities in order to assess to the most thorough extent possible the likely maneuvering and launch environments of a HAC aircraft. If this is not done, there is a high probability that any open-loop research program not coordinated with those communities will involve much wasted effort.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: NA  
DTIC AD NUMBER: ATI (AIR TECHNICAL INTELLIGENCE--A DESIGNATION NOW OBSOLETE) 79310  
SOURCE NAME: U.S. NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL

ACCESSION NUMBER: 89-454  
SOURCE NAME: U.S. NEWS AND WORLD REPORT

TITLE: TURNING ON A DIME IN MID-AIR: NEW FIGHTERS THAT BEND THE LAWS OF AERODYNAMICS

PERSONAL AUTHORS: COOK, W.J.

REPORT DATE: 89/02/20  
PAGINATION: 5  
SUPPLEMENTARY NOTE: MAGAZINE ARTICLE  
DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: ARTICLE INTENDED FOR THE LAY PUBLIC CONCERNING THE POTENTIAL OF NEW, SUPERMANEUVERABILITY AIRCRAFT CAPABLE OF MANEUVERING IN THE POST-STALL REGIME. TACTICS, AERODYNAMICS, MBB/ROCKWELL DEVELOPMENT EFFORT AND THE HERBST MANEUVER ARE DISCUSSED.

ACCESSION NUMBER: NA  
TITLE: A DEVICE FOR THE AUTOMATIC CONTROL BY G FORCE OF THE POSITION OF THE CONTROLLABLE SUPINE SEAT  
PERSONAL AUTHORS: KELLEY, R.E., AND STAUFFER, F.R.  
REPORT DATE: 50/03  
REPORT SERIES NUMBER: PROJECT NM 001 059.02.05  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT SDC PROJECT 9-U-37A  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

ABSTRACT: DESCRIBES AN AUTOMATICALLY SUPINATING SEAT. VERY GOOD INFORMATION ON SEAT MOTION. ALTERING THE SEAT BACK ANGLE OVER THE AVAILABLE RANGE OF MOTION UNDER UP TO +5Gz WAS WELL TOLERATED OVER A 2 SEC. PERIOD OF TIME. POTENTIAL IMPLICATIONS FOR CONCERNS ABOUT PILOT ANGULAR MOTION IN THE X-Z AXES IN SUPERMANEUVERABILITY MANEUVERS AND TACTICS.

ACCESSION NUMBER: 4578  
AD: A  
AD NUMBER: 008497  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB, WRIGHT-PATTERSON AFB, OHIO

TITLE: ADVANCED MANEUVERABILITY OPTIONS FOR FUTURE FIGHTERS.

PERSONAL AUTHORS: KULWICKI, P.V., AND SINNETT, J.M.

REPORT DATE: 75/03  
PAGINATION: 35P  
REPORT SERIES NUMBER: AMRL-TR-74-140  
SUPPLEMENTARY NOTE: PRESENTED AT AVIONICS SECTION MEETING, AMERICAN DEFENSE PREPAREDNESS ASSOC., POINT MUGU, CALIF. 20-21 NOV 74.  
DESCRIPTIVE NOTE: SUMMARY REPT.

ABSTRACT: RECENT DEVELOPMENTS IN FIGHTER DESIGN TECHNOLOGY HAVE EMPHASIZED AIR COMBAT MANEUVERABILITY. HIGH THRUST-TO-WEIGHT RATIO ENGINES, ADVANCED LIGHTWEIGHT STRUCTURES, IMPROVED AERODYNAMIC EFFICIENCIES AND EFFECTIVE FLIGHT CONTROL SYSTEMS DEVELOPMENTS ENABLE REALIZATION OF MORE RESPONSIVE, HIGHER LEVELS OF AIR COMBAT MANEUVERABILITY THAN EVER BEFORE SEEN IN FIGHTER AIRCRAFT. PARALLEL DEVELOPMENTS IN HIGH ACCELERATION AND ADVANCED COCKPIT TECHNOLOGIES WITHIN THE AEROMEDICAL AND ENGINEERING COMMUNITIES HAVE ILLUMINATED THE ABILITY TO REALIZE SIGNIFICANT IMPROVEMENTS IN PERFORMANCE LEVELS FOR FUTURE TACTICAL FIGHTERS.

ACCESSION NUMBER: 4761  
AD NUMBER: 770287  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB, WRIGHT-PATTERSON AFB, OHIO



**TITLE:** HIGH ACCELERATION COCKPIT - THE MANEUVERING COUNTERMEASURE

**PERSONAL AUTHORS:** KULWICKI, P.V., LYONS, J.P., AND RAVENELLE, R.L.

**REPORT DATE:** 73/09  
**PAGINATION:** 18P  
**REPORT SERIES NUMBER:** AMRL-TR-73-93  
**SUPPLEMENTARY NOTE:** PRESENTED AT THE AFSC SCIENCE AND ENGINEERING SYMPOSIUM (1973), KIRTLAND AFB, N. MEX., 2-4 OCT 73.

**ABSTRACT:** THE HIGH ACCELERATION COCKPIT REPRESENTS AN INNOVATIVE APPROACH TO COCKPIT DESIGN WHICH PROVIDES A UNIQUE BLEND OF PILOT CAPABILITIES AND AIRPLANE PERFORMANCE POTENTIAL, ESPECIALLY FOR THE COUNTER AIR MISSION. BY ALTERING THE STANDARD COCKPIT GEOMETRY, POSITIVE AIRPLANE CONTROL AND TACTICAL DECISIONS ARE ENABLED DURING LEVELS OF MANEUVERING ACCELERATION WELL ABOVE +7 GZ. THE RESULT, IN THE CONTEXT OF EMERGING FIGHTER CAPABILITY, IS A DRAMATIC INCREASE IN COMBAT EFFECTIVENESS AND OPERATIONAL ADVANTAGE.

**ACCESSION NUMBER:** 4819  
**AD NUMBER:** 757216  
**SOURCE NAME:** MCDONNELL AIRCRAFT CO., ST LOUIS, MO

**TITLE:** THE HIGH G APPROACH.

**PERSONAL AUTHORS:** KULWICKI, P.V., AND SINNETT, J.M.

**REPORT DATE:** 73/02/20  
**PAGINATION:** 27P  
**REPORT SERIES NUMBER:** MDC-A2169  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-73-27  
**DESCRIPTIVE NOTE:** SUMMARY REPT.

**ABSTRACT:** THE HIGH G APPROACH IS AN INNOVATIVE APPROACH TO COCKPIT DESIGN WHICH PROVIDES A UNIQUE MATCH OF PILOT CAPABILITIES AND AIRPLANE PERFORMANCE POTENTIAL. THE HIGH G APPROACH PROVIDES AN OPTION FOR THE PILOT TO THINK, COMMAND AND CONTROL HIS AIRCRAFT AT SUSTAINED LOAD FACTOR LEVELS WELL ABOVE 7 G. THE RESULT, IN THE CONTEXT OF EMERGING FIGHTER CAPABILITY, IS A DRAMATIC INCREASE IN COMBAT EFFECTIVENESS AND OPERATIONAL ADVANTAGE.

**ACCESSION NUMBER:** 4226  
**AD:** A  
**AD NUMBER:** 045165  
**SOURCE NAME:** MCDONNELL DOUGLAS CO., ST LOUIS, MO

**TITLE:** HIGH ACCELERATION COCKPIT SIMULATOR EVALUATION.

**PERSONAL AUTHORS:** PROUHET, E.P., AND KULWICKI, P.V.

**REPORT DATE:** 77/06  
**PAGINATION:** 7P

**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-75-123  
**DESCRIPTIVE NOTE:** SUMMARY REPT.  
**ABSTRACT:** SINCE 1970, THE AEROSPACE MEDICAL RESEARCH LABORATORY (AMRL) AND THE AIR FORCE FLIGHT DYNAMICS LABORATORY (AFFDL) HAVE JOINTLY SPONSORED A UNIQUE AND INNOVATIVE APPROACH TO FIGHTER COCKPIT DESIGN TERMED THE HIGH ACCELERATION COCKPIT (HAC). AS A RESULT OF INDICATED IMPROVEMENTS IN PILOT-VEHICLE COMPATIBILITY DURING AND FOLLOWING EXPOSURE TO MODERATE-TO-HIGH G FORCE FIELDS, HAC IS ENTERING A STAGE OF ADVANCED DEVELOPMENT AND PLANNED FLIGHT DEMONSTRATION BY AFFDL. IMPROVED PILOT CAPABILITY WITH HAC RESULTS FROM REPOSITIONING THE PILOT TO PLACE HIM IN A MORE FAVORABLE POSITION WITH RESPECT TO THE APPLIED LOADS, THEREBY REDUCING THE CHANCE OF GRAYOUT AND BLACKOUT AS WELL AS IMPROVING TRACKING ABILITY AND RESISTANCE TO BODY FATIGUE. THE MATERIAL PRESENTED HEREIN IS FROM A COMPREHENSIVE MANNED SIMULATOR ASSESSMENT OF THE TACTICAL UTILITY AND COMBAT CAPABILITY PROJECTED FOR THE HAC CONCEPT. SYSTEMS WERE COMPLETELY MODELED, INCLUDING AIRCRAFT AND WEAPON DYNAMICS, COCKPIT WITH FLIGHT CONTROL AND FIRE CONTROL SYSTEMS. A FULL COMPLEMENT OF OFFENSIVE AND DEFENSIVE SITUATION DISPLAYS AND CUES WERE PROVIDED TO COVER ALL ASPECTS OF THE SIMULATED COMBAT. SELECTED RESULTS ARE PRESENTED TO ILLUSTRATE THAT, RELATIVE TO CONVENTIONAL COCKPIT DESIGN, THE CONFIGURATION EMPLOYING HAC WAS ABLE TO DECISIVELY CONTROL THE ENGAGEMENTS.

**ACCESSION NUMBER:** 3748  
**AD:** C  
**AD NUMBER:** 007496  
**SOURCE NAME:** MCDONNELL AIRCRAFT CO., ST LOUIS, MO  
**TITLE:** HIGH ACCELERATION COCKPIT SIMULATOR EVALUATION.  
PART 2. AIR COMBAT CAPABILITIES.

**PERSONAL AUTHORS:** PROUHET, E.P., LEONARD, J.M., GREENBERG, S.M.,  
GUTHRIE, H.C., AND LEONARD, J.M.

**REPORT DATE:** 76/05  
**PAGINATION:** 127P  
**REPORT SERIES NUMBER:** REPT NO. MDC-A3412-PT-2  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-75-122  
**DIST/AVAIL STATEMENT:** DISTRIBUTION LIMITED TO U.S. GOV'T. AGENCIES ONLY;  
TEST AND EVALUATION; MAY 76. OTHER REQUESTS FOR THIS  
DOCUMENT MUST BE REFERRED TO DIRECTOR, CREW SYSTEMS  
DIRECTORATE, ARMSTRONG LABORATORY, ATTN: AL/CFHV,  
WRIGHT-PATTERSON AFB, OHIO 45433.

**ABSTRACT:** UNAVAILABLE WHEN ENTERED IN THIS DATABASE

**ACCESSION NUMBER:** 45158  
**AD:** A  
**AD NUMBER:** 152468  
**SOURCE NAME:** MESSERSCHMITT BOELKOW BLOHM GMBH, MUNICH, GERMANY  
**TITLE:** IMPACT OF FUTURE AIR COMBAT CHARACTERISTICS ON PILOT  
PERFORMANCE AND COCKPIT DESIGN

PERSONAL AUTHORS: RICHTER, K.D.

REPORT DATE: 84/04/30  
PAGINATION: 15P  
REPORT SERIES NUMBER: AGARD-CP-371  
SUPPLEMENTARY NOTE: AGARD AEROSPACE MEDICAL PANEL SYMPOSIUM HELD IN WILLIAMSBURG, VA, 30 APRIL - 2 MAY 1984  
DIST/AVAIL STATEMENT: PUB. IN AGARD CONFERENCE PROCEEDINGS NO. 371, HUMAN FACTORS CONSIDERATIONS IN HIGH PERFORMANCE AIRCRAFT (ACC NO 45150), P9-1 - 9-15. AUTHOR AFFILIATED WITH MESSERSCHMITT

ABSTRACT: FUTURE MEDIUM-RANGE (MR) AND SHORT-RANGE (SR) WEAPONS ARE EXPECTED TO CHANGE AIR COMBAT CHARACTERISTICS SIGNIFICANTLY. MR WEAPON TECHNOLOGY AND PERFORMANCE WILL FORCE A SUPERSONIC MANEUVERING TYPE AIR COMBAT WITH SUSTAINED ENERGY AS WELL AS HIGH DYNAMIC CHARACTER IN TERM OF CLIMB/DESCENT RATES AND SPATIAL POSITION CHANGES. THE SR-AIR COMBAT IS CHARACTERIZED BY INSTANTANEOUS MANEUVERING AND IS DRIFTING TO LOWER SPEEDS AND LOWER LOADFACTOR LEVELS. A TACTICAL INFORMATION & COMMAND SYSTEM IS DISCUSSED AND A TACTICAL DISPLAY LAYOUT PROPOSED.

ACCESSION NUMBER: 89-455  
SOURCE NAME: POPULAR SCIENCE

TITLE: X-31: HOW THEY'RE INVENTING A RADICAL NEW WAY TO FLY

PERSONAL AUTHORS: SCHEFTER, J.

REPORT DATE: 89/02/00  
PAGINATION: 7  
SUPPLEMENTARY NOTE: MAGAZINE ARTICLE  
DIST/AVAIL STATEMENT: FROM SOURCE

ABSTRACT: POPULAR PRESS ARTICLE ON THE CAPABILITIES OF NEW, SUPERMANEUVERABILITY AIRCRAFT CAPABLE OF MANEUVERING IN THE POST-STALL REGIME.

ACCESSION NUMBER: 6164  
AD NUMBER: 529384  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST LOUIS, MO

TITLE: ADVANCED FIGHTER CONCEPTS INCORPORATING HIGH ACCELERATION COCKPITS. VOLUME II. BASELINE DESIGN AND PERFORMANCE.

PERSONAL AUTHORS: SINNETT, J.M., AND SCHELLER, D.M.

REPORT DATE: 73/07  
PAGINATION: 130P  
REPORT SERIES NUMBER: MDC-A1685-VOL-2  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-72-114  
SUPPLEMENTARY NOTE: SEE ALSO VOLUME 3, AD-529 385L.

**ABSTRACT:** IN THIS VOLUME, ADVANCED CONVENTIONAL FIGHTER AND HIGH ACCELERATION FIGHTER DESIGN AND PERFORMANCE CHARACTERISTICS WERE ADDRESSED. COMPARATIVE MISSION AND MANEUVERING PERFORMANCE FOR THESE CONCEPTS WAS DETERMINED. AN ISOLATED ASSESSMENT OF THE IMPACT OF INCREASED MANEUVERING LOAD FACTOR CAPABILITY ON AIRCRAFT PERFORMANCE WAS PROVIDED, AND AN EXAMPLE OF THE EFFECTIVE USE OF HIGH G POTENTIAL SHOWN.

**ACCESSION NUMBER:** 6163  
**AD NUMBER:** 529385  
**SOURCE NAME:** MCDONNELL AIRCRAFT CO., ST LOUIS, MO

**TITLE:** ADVANCED FIGHTER CONCEPTS INCORPORATING HIGH ACCELERATION COCKPITS. VOLUME III. HIGH G PERFORMANCE COMPARISONS.

**PERSONAL AUTHORS:** SINNETT, J.M., AND SINNOTT, J.J.

**REPORT DATE:** 73/07  
**PAGINATION:** 127P  
**REPORT SERIES NUMBER:** MDC-A1685-VOL-3  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-72-115  
**SUPPLEMENTARY NOTE:** SEE ALSO VOLUME 4, AD-913 694L.

**ABSTRACT:** THIS VOLUME PRESENTS THE RESULTS OF THE COMPARATIVE CAPABILITY ANALYSES PERFORMED DURING THE STUDY OF ADVANCED FIGHTER CONCEPTS, INCORPORATING HIGH ACCELERATION COCKPITS. INFORMATION IS PRESENTED ON THE BENEFITS OF HIGH G'S DURING CLOSE-IN DUELING COMBAT WITH AN ADVANCED CAPABILITY OPPONENT. PERFORMANCE AND COMBAT CAPABILITY COMPARISONS ARE DRAWN BETWEEN THE HIGH ACCELERATION FIGHTER (HAF) AND AN ADVANCED CONVENTIONAL FIGHTER (ACF), WITH PRIMARY EMPHASIS PLACED ON THE GUNS-ONLY COMBAT ENVIRONMENT. DIGITALLY SIMULATED DUELING ENGAGEMENTS, WITH PILOT PHYSIOLOGICAL LIMITS INCORPORATED, ARE DESCRIBED WITH APPROPRIATE DISCUSSIONS OF SIMULATION METHODOLOGY. IN ADDITION TO THE COMBAT CAPABILITY ASSESSMENTS, PILOT PERFORMANCE AND TASK WORKLOAD ANALYSES SUMMARIES ARE ALSO PRESENTED, COMPARING THE HAF AND ACF AIRCRAFT AS RELATED TO PILOT PERFORMANCE ENHANCEMENT.

**ACCESSION NUMBER:** 4613  
**AD NUMBER:** 913694  
**SOURCE NAME:** MCDONNELL AIRCRAFT CO., ST LOUIS, MO

**TITLE:** ADVANCED FIGHTER CONCEPTS INCORPORATING HIGH ACCELERATION COCKPITS. VOLUME IV. PILOT PERFORMANCE ANALYSES.

**PERSONAL AUTHORS:** SINNETT, J.M., AND ASIALA, C.F.

**REPORT DATE:** 73/07  
**PAGINATION:** 154P  
**REPORT SERIES NUMBER:** MDC-A1685-VOL-4  
**MONITOR ACRONYM:** AMRL  
**MONITOR SERIES:** AMRL-TR-72-116

SUPPLEMENTARY NOTE: SEE ALSO VOLUME 5, AD-913 695L.

ABSTRACT: THE STUDY INVESTIGATED PILOT PERFORMANCE ENHANCEMENT (THROUGH APPLICATION OF AN ARTICULATED SEAT CONCEPT) AS RELATED TO PILOT TASK WORKLOAD IN A HIGH G COMBAT ENVIRONMENT. THE APPROACH TAKEN TO SATISFY SEVERAL STUDY OBJECTIVES WAS UTILIZATION OF THE MCDONNELL DOUGLAS CORPORATION PILOT SIMULATION MODEL. THIS MODEL DEPICTED ALL OF THE DETAILED PILOT FUNCTIONS, THEIR INTERRELATIONSHIPS AND THE POTENTIAL ALTERNATE OR ITERATING LOOPS. AS A RESULT OF INTERFACING WITH AIR BATTLE SIMULATION II MODEL, AIR BATTLE KINEMATICS AND DYNAMIC SEQUENCING ENABLED THE DEFINITION OF PILOT TASK AND TASK LOADING DURING COMBAT ENGAGEMENTS. THE INTERACTION BETWEEN THE MODELS, ADVANCED SYSTEM DESIGN AND INTEGRATION AND VERIFICATION OF THE FEASIBILITY USING SIMULATOR DESIGN AID PROVIDED A NEAR TERM, ADVANCED HIGH ACCELERATION CREW STATION DESIGN.

ACCESSION NUMBER: 3747  
AD: C  
AD NUMBER: 007920  
SOURCE NAME: MCDONNELL AIRCRAFT CO., ST LOUIS, MO

TITLE: HIGH ACCELERATION COCKPIT SIMULATOR EVALUATION. PART 1. BASIS FOR AIR COMBAT EVALUATION.

PERSONAL AUTHORS: SINNETT, J.M., PROUHET, E.P., BERGER, R.L., HALLEY, T., AND MARSHALL L.E.

REPORT DATE: 76/05  
PAGINATION: 127P  
REPORT SERIES NUMBER: MDC-A3412-PT-1  
MONITOR ACRONYM: AMRL  
MONITOR SERIES: AMRL-TR-75-121  
SUPPLEMENTARY NOTE: SEE ALSO PART 2, AD-C007 496L.  
DIST/AVAIL STATEMENT: DISTRIBUTION LIMITED TO U.S. GOV'T. AGENCIES ONLY; TEST AND EVALUATION; MAY 76. OTHER REQUESTS FOR THIS DOCUMENT MUST BE REFERRED TO DIRECTOR, CREW SYSTEMS DIRECTORATE, ARMSTRONG LABORATORY, ATTN: CFHV. WRIGHT-PATTERSON AFB, OHIO 45433.

ACCESSION NUMBER: NA  
DTIC AD NUMBER: 76458  
SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL

TITLE: CERTAIN PHYSIOLOGICAL RESPONSES IN MAN CHANGING FROM THE SITTING TO THE SUPINE POSITION DURING RADIAL ACCELERATORY FORCE

PERSONAL AUTHORS: STAUFFER, F.R.

REPORT DATE: 50/03  
REPORT SERIES NUMBER: PROJECT NM 001 059.02.02  
SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL TECHNICAL INFORMATION SERVICE

**ABSTRACT:** REPORTS NO ADVERSE EFFECT ON PILOT VESTIBULAR SENSES WHEN RAPIDLY SUPINATING A G-CONTROLLABLE SEAT UNDER SUSTAINED ACCELERATION AT UP TO +5Gz. CONCLUDES THERE IS NO VESTIBULAR OR SPATIAL DISORIENTATION REASON NOT TO USE THIS SEAT CONCEPT OPERATIONALLY AS AN ACCELERATION PROTECTION METHOD. SEE ALSO A SIMILAR PAPER BY KELLY, R.E., AND STAUFFER, F.R. THIS INFORMATION ALSO HAS IMPLICATIONS FOR SUPERMANEUVERABILITY TACTICS AND MANEUVERS.

**ACCESSION NUMBER:** 7880  
**AD:** A  
**AD NUMBER:** 145439  
**SOURCE NAME:** AF AEROSPACE MEDICAL RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH

**TITLE:** THE HIGH ACCELERATION COCKPIT (HAC): A TECHNOLOGY BASE OVERVIEW - 1983

**PERSONAL AUTHORS:** VAN PATTEN, R.E., JENNINGS, T.J., AND MAXWELL, M.

**REPORT DATE:** 83/06  
**PAGINATION:** 5P  
**REPORT SERIES NUMBER:** AFAMRL-TR-84-075  
**SUPPLEMENTARY NOTE:** SAFE ASSOCIATION MEETING, 5-8 NOV 83, SAN ANTONIO, TX  
**DIST/AVAIL STATEMENT:** PUB. IN 1983 SAFE ASSOCIATION PROCEEDINGS (ACCESS NO. 10742), P 43-47; ALSO PUB. IN SAFE JOURNAL 14(2):16-21 SUMMER QUARTER 1984

**ACCESSION NUMBER:** 45811  
**SOURCE NAME:** ARMSTRONG AEROSPACE MEDICAL RESEARCH LABORATORY, WRIGHT-PATTERSON AFB, OH

**TITLE:** HUMAN FACTORS AND PERFORMANCE ISSUES IN THE DESIGN OF HIGH PERFORMANCE FIGHTER AIRCRAFT COCKPITS

**PERSONAL AUTHORS:** VAN PATTEN, R.E.

**REPORT DATE:** 85/10/11  
**PAGINATION:** 12P  
**SUPPLEMENTARY NOTE:** PRESENTED AT THE 4TH INTERNATIONAL CONFERENCE ON AVIATION PHYSIOLOGY, SPONSORED BY THE ENVIRONMENTAL TECTONICS CORP. SOUTHAMPTON, PA, 11-18 OCTOBER 1985

**ABSTRACT:** OVER THE FIRST SEVEN DECADES OF THIS CENTURY, THE COMPLEXITY OF THE AIRCRAFT COCKPIT AND THE LEVEL OF PERFORMANCE OF THE AIRCRAFT HAVE BOTH INCREASED MANY-FOLD. MAN HAS NOT UNDERGONE A CORRESPONDING PERFORMANCE UPGRADE AND THE POINT HAS BEEN REACHED AT WHICH COCKPIT DESIGN WILL HAVE TO ALTER MARKEDLY IN ORDER TO EXPLOIT MAN'S FULL POTENTIAL AS WELL AS THAT OF THE AIRFRAME. THIS PAPER DISCUSSES SPECIFIC PERFORMANCE TASKING IN THE AIR COMBAT ENVIRONMENT, INCLUDING OFFENSIVE/DEFENSIVE MANEUVERING, WEAPON SELECTION/MANAGEMENT, PILOT MOBILITY, VISION, SITUATIONAL AWARENESS. PHYSIOLOGICAL EFFECTS OF HIGH ONSET RATE, HIGH SUSTAINED ACCELERATION ARE DISCUSSED WITH RESPECT TO THESE TASKS, INCLUDING A DISCUSSION OF THE INFLUENCE

OF TASK DIFFICULTY AND REALISM ON THE ASSESSMENT OF PERFORMANCE. TECHNIQUES FOR THE ENHANCEMENT OF PERFORMANCE ARE DISCUSSED INCLUDING ANTI-G SUITS AND VALVES, POSTURE, PHYSIOLOGICAL SELF-PROTECTION MANEUVERS, POSITIVE PRESSURE BREATHING, AND PHARMACOLOGY. THIS PAPER CONCLUDES WITH A REVIEW AND COMPARISON OF PERFORMANCE WORK DONE IN RADICALLY RECLINED SEATS IN U.S. AND U.K. LABORATORIES.

## HIGH ACCELERATION COCKPIT RESEARCH

### SUSTAINED ACCELERATION TOLERANCE AND PHYSIOLOGY VIBRATION ENVIRONMENTS

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

This section does not include the vast literature which pertains only to human tolerance to +Gx acceleration except in cases in which that stressor was applied in an investigation of reclined seats.

Physiologically, there is little doubt concerning the general level of tolerance which can be obtained by the use of all available protection modalities in conjunction with a reclined seat. Barer, et al cite +22Gx/50 sec., and +26.5Gx/8 sec. using a seat with an 80° backangle, but note that arterial oxygen saturation drops to 62% within 60 seconds in such a seat at +12Gx.

As noted in earlier studies by others, Burns observed insignificant benefit at any backangle up to 45°, but observed a 100% increase in tolerance using a 75° backangle during an +8Gz exposure. Wieshofer, in one of the very earliest experiments, was able to extend endurance from +8 to +10Gz exposures for up to 10 seconds, and did limited studies at +15Gx while noting that respiratory pain limited endurance at that level.

Notwithstanding, some aeromedical opinions that a reclined head position is mandatory in order to obtain all the benefits of a HAC seat, it is clear that an erect head position is mandatory in an operational seat. In any case, Crossley, et al, and Glaister state that head position is virtually insignificant in the radically reclined seats they tested. It appears pointless to pursue research on a HAC cockpit using a seat with anything but an upright head position since the likelihood of acceptance is thought to be virtually nil. Crossley speculated about relaxed tolerance levels of 6 to 8G in a nearly supine (they used a 70° backangle) and went on to state that the +Gx encountered during ejection would be an additional advantage. That position should be clarified with regard to current ejection seat thinking.

Other than von Beckh's work on the PALE seat, there appears to be little pertaining to the question of heel line and the PALE seat reports should be studied in detail prior to commencement of new research. In any seat with an elevated heel position, it must be remembered that provision must be made for clearing the instrument panel/pod and cockpit structure during ejection. This will complicate any high heel position design and the benefits will have to be compared to the practical cost of execution.

There remains the controversy between the work of Nelson and Burton concerning the nature of the hydrostatic model used to predict group tolerance. The published differences must be reconciled prior to the commencement of new research.



Additionally, there are the complicating factors published in the work of Wood, et al, reporting tolerance improvements in reclined seats at much lower values than would be predicted by a hydrostatic model. An early step in any future program will be a discussion/study/resolution of this issue.

#### LITERATURE BIBLIOGRAPHY

ACCESSION NUMBER: 48787  
SOURCE NAME: U.S. NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA  
TITLE: DEVELOPMENT OF SUPINE SEAT AND RELATED COMPONENTS  
REPORT DATE: 55/11/30  
PAGINATION: 7P  
REPORT SERIES NUMBER: NADC-MA-3-13169  
DESCRIPTIVE NOTE: LETTER REPORT

ABSTRACT: WITH 65 DEGREES SUPINATION, STRAINING AND A Z-2 ANTIBLACKOUT SUIT, THE TOLERANCE FOR 100% OF THE PILOTS TESTED (REGARDLESS OF UNPROTECTED G TOLERANCE) CAN BE RAISED TO ACCELERATION STRESS CONDITIONS UP TO 7 GZ FOR 30 SECONDS.

ACCESSION NUMBER: NA  
SOURCE NAME: XV INTERNATIONAL ASTRONAUTICAL CONGRESS, WARSAW, POLAND SEPT 7-12, 1964

TITLE: PHYSIOLOGICAL REACTIONS OF THE HUMAN ORGANISM TO TRANSVERSE ACCELERATION AND MEANS OF RAISING RESISTANCE...(INCOMPLETE TITLE)

PERSONAL AUTHORS: BARER, A.S., GOLOV, G.A., ZUBAVIN, V.B., MURAKOVSKIY, K.T., RODIN, S.A., ET ALIA

REPORT DATE: 640907  
SUPPLEMENTARY NOTE: PRESENTED PAPER  
DIST/AVAIL STATEMENT: ENGLISH TRANSLATION AVAILABLE NTIS

ABSTRACT: THIS PAPER CITES +22Gx FOR A DURATION OF 50 SECONDS, AND +26.5Gx FOR A DURATION OF 8 SECONDS AS THE HUMAN TOLERANCE LIMIT WITH AN 80° SEAT BACK ANGLE BETWEEN THE ACCELERATION VECTOR AND THE BODY. CONTAINS MANY GRAPHS AND A DISCUSSION OF THE CENTRIFUGE EXPERIMENTS.

ACCESSION NUMBER: NA  
SOURCE NAME: TRANSACTIONS OF THE 17TH INTERNATIONAL ASTRONAUTICAL CONGRESS, MADRID, SPAIN, OCT. 9-15, 1966

TITLE: OXYGEN BALANCE OF THE BODY DURING EXTENDED ACCELERATION

PERSONAL AUTHORS: BARER, A.S., GOLOV, G.A., ZUBAVIN, V.B., SOROKINA, Y.E.I., AND TIKHOMIROV, Y.E.P.

REPORT DATE: 66/10/09  
SUPPLEMENTARY NOTE: PRESENTED PAPER  
DIST/AVAIL STATEMENT: SOURCE

ABSTRACT: REPORTS STUDIES DONE UNDER SUSTAINED ACCELERATIONS RANGING FROM +4 TO +12Gz USING A SEAT WITH AN 80 DEGREE SEAT BACK ANGLE. ARTERIAL OXYGEN SATURATION VALUE AT +12Gz WAS OBSERVED TO DROP TO 62% IN LESS THAN A MINUTE. (ED. NOTE: OTHER SUSTAINED ACCELERATION RESEARCH HAS OBSERVED DEFICITS IN COGNITIVE FUNCTIONS WHEN THE ARTERIAL OXYGEN SATURATION DROPS TO APPROXIMATELY 80%)

ACCESSION NUMBER: NA  
SOURCE NAME: LUFTFAHRTMEDIZIN 1:307-326 (1936-1937)

TITLE: VERSUCHE UBER DIE BEDEUTUNG DER RICHTUNG BEIM EINWERKEN VON FLIEHKRAFTEN (STUDY CONCERNING THE SIGNIFICANCE OF THE DIRECTION OF INFLUENCE OF CENTRIFUGAL FORCE)

PERSONAL AUTHORS: BURHLEN, L.

REPORT DATE: 36  
PAGINATION: 19  
SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
DIST/AVAIL STATEMENT: POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS

ABSTRACT: HAC, HIGH ACCELERATION COCKPIT RECLINED SEATS-SEE ALSO: BURHLEN L. VERSUCHE UBER DIE BEDEUTUNG DER RICHTUNG BEIM EINWIRKUNG VON FLIEHKRAFTEN AUF DEN MENSCHLICHEN KORPER. LUFTFAHRTMEDIZIN 1937; 2:307-25. REPORTS SUBJECTS TOLERATED 8-10G FOR 10S; UP TO 15G BUT BREATHING NOT POSSIBLE AT THAT LEVEL. NO INFORMATION ON BACK ANGLE.

ACCESSION NUMBER: NA  
SOURCE NAME: LUFTFAHRTMEDIZIN 2:287-90 (1937-1938)

TITLE: SPITZENBESCHLEUNIGUNGEN IN ZWEI VERSCHIEDENEN LAGE (PEAK ACCELERATION IN TWO DIFFERENT POSITIONS)

PERSONAL AUTHORS: BUHRLIN, L.

REPORT DATE: 36  
PAGINATION: 4  
SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
DIST/AVAIL STATEMENT: POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS

ABSTRACT: NO ABSTRACT AVAILABLE WHEN ENTERED IN THIS DATABASE

ACCESSION NUMBER: 784  
AD: A  
AD NUMBER: 008226  
SOURCE NAME: SCHOOL OF AEROSPACE MEDICINE BROOKS AFB, TX

**TITLE:** A RE-EVALUATION OF A TILT-BACK SEAT AS A MEANS OF INCREASING ACCELERATION TOLERANCE.

**PERSONAL AUTHORS:** BURNS, J.W.  
**REPORT DATE:** 74  
**PAGINATION:** 11P  
**REPORT SERIES NUMBER:** SAM-TR-74-285  
**DIST/AVAIL STATEMENT:** PUB. IN AVIATION, SPACE AND ENVIRONMENTAL MEDICINE, V46 N1 P55-63 JAN 75. NLM-75108705 JOURNAL CODE:9JA

**ABSTRACT:** RELAXED TOLERANCE WAS DETERMINED ON SEVEN SUBJECTS EXPOSED TO RAPID ONSET (RO; 1G/SEC) AND GRADUAL ONSET (GO; 1G/10 SEC) ACCELERATION AT SEAT BACK ANGLES OF 13, 30, 45, 55, 65, AND 75 DEG FROM THE VERTICAL. THERE WAS NO SIGNIFICANT DIFFERENCE BETWEEN RELAXED TOLERANCE AT THE CONTROL ANGLE OF 13 DEG AND TOLERANCE AT 30 DEG. HOWEVER, AT 45 DEG THERE WAS A SIGNIFICANT +0.5 GZ INCREASE IN TOLERANCE COMPARED TO CONTROL. THEREAFTER, TOLERANCE CONTINUED TO INCREASE IN AN EXPONENTIAL MANNER TO +8 GZ AT 75 DEG, AN INCREASE OVER CONTROL OF 100.8%. AS RELAXED TOLERANCE INCREASED WITH INCREASING BACK ANGLE, PEAK HEART RATE DURING ACCELERATION SIGNIFICANTLY DECREASED. IN ADDITION, FOUR SUBJECTS WERE INSTRUMENTED WITH AN ESOPHAGEAL BALLOON FOR THE MEASUREMENT OF INTRATHORACIC PRESSURE WHICH WAS EQUATED AS WORK DURING THE M-1 STRAINING MANEUVER. THE AMOUNT OF THORACIC PRESSURE NECESSARY TO MAINTAIN A PRESELECTED VISUAL FIELD DECLINED AS THE BACK ANGLE WAS INCREASED FROM 13 TO 45 DEG TO 65 DEG AT THE SAME ACCELERATION LEVEL. THE INCREASE IN RELAXED TOLERANCE ALONG WITH THE DECREASE IN HEART RATE AND THE DECREASE IN ESOPHAGEAL PRESSURE AT THE GREATER BACK ANGLES ALL DEMONSTRATE THE ACCELERATION PROTECTION PROVIDED BY THE TILT-BACK SEAT.

**ACCESSION NUMBER:** 10612  
**AD:** A  
**AD NUMBER:** 140048  
**SOURCE NAME:** AEROSPACE RESEARCH BRANCH, USAF SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TX

**TITLE:** SIGNIFICANCE OF HEADREST GEOMETRY IN + GZ PROTECTIVE SEATS

**PERSONAL AUTHORS:** BURNS, J.W., AND WHINNERY, J.E.  
**REPORT DATE:** 84/02  
**PAGINATION:** 6P  
**REPORT SERIES NUMBER:** USAFSAM-TR-83-284  
**DIST/AVAIL STATEMENT:** AVIATION, SPACE AND ENVIRON. MEDICINE, VOL 55, NO 2, P 122-127, FEBRUARY 1984

**ABSTRACT:** AN X-RAY TECHNIQUE WAS USED TO DETERMINE THE VERTICAL HYDROSTATIC COLUMN LENGTH (H) BETWEEN THE EYE AND THE PROSTHETIC AORTIC VALVE OF SEVEN SUBJECTS AT THREE DIFFERENT EXPERIMENTAL HEADREST GEOMETRIES AT 30 AND 65 DEGREE SEATBACK ANGLES. THE H FROM THESE SUBJECTS WAS THEN USED TO EXPLAIN RELAXED +GZ TOLERANCE DATA ACQUIRED FROM OTHER SUBJECTS AT THE SAME SEATING GEOMETRIES. THERE WAS A VERY SIGNIFICANT CORRELATION ( $R=0.99$ ,  $P<<0.001$ ) BETWEEN  $1/H$  AND RELAXED +GZ TOLERANCE. CHANGING THE SEATBACK ANGLE FROM 30 TO 65 RESULTED IN A 35.6%, 19.8%, AND 24.1% DECREASE IN H AND A CORRESPONDING 69.2% (3.9 GZ TO 6.6 GZ), 30.3% (3.73 GZ TO 4.86 GZ), AND 36.4%

(3.98 GZ TO 5.43 GZ) INCREASE IN RELAXED +GZ TOLERANCE FOR THE THREE DIFFERENT HEADREST GEOMETRIES, RESPECTIVELY. THESE DATA DEMONSTRATE THAT HEADREST GEOMETRY IS AN IMPORTANT CONSIDERATION IN OBTAINING THE OPTIMUM REDUCTION IN H WITHIN THE OPERATIONAL CONSTRAINTS OF THE COCKPIT.

ACCESSION NUMBER: 47709  
SOURCE NAME: CREW TECHNOLOGY DIVISION, USAF SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TX

TITLE: A CONCEPTUAL MODEL FOR PREDICTING PILOT GROUP G TOLERANCE FOR TACTICAL FIGHTER AIRCRAFT

PERSONAL AUTHORS: BURTON, R.R.

REPORT DATE: 86/08  
PAGINATION: 12P  
DIST/AVAIL STATEMENT: PUB. IN AVIAT SPACE ENVIRON MED 57:733-744, AUGUST 1986

ABSTRACT: A STATIC MODEL BASED ON EYE-HEART VERTICAL DISTANCE HAS BEEN DEVELOPED WHICH PREDICTS GROUP MEAN G TOLERANCES RELATIVE TO THE APPLICATION OF ANY OF THE FOLLOWING ANTI-G METHODS AND/OR PHYSIOLOGIC RESPONSES: A) ANTI-G SUIT, B) RECLINED SEAT, C) ANTI-G STRAINING MANEUVER (AGSM), D) POSITIVE PRESSURE BREATHING (PPB), E) GRADUAL ONSET OF G, F) ISOMETRIC MUSCULAR CONTRACTION, AND G) LEG ELEVATION. THIS MODEL WAS VALIDATED WITH PUBLISHED DATA. A VARIATION OF THIS MODEL (DERIVED EQUATION) PREDICTS THE AMOUNT OF AGSM (IN MMHG) REQUIRED, IN COMBINATION WITH ANY OF THE ANTI-G METHODS/RESPONSES AT ANY G LEVEL. THIS CALCULATED EFFORT OF AGSM CAN BE EQUATED TO LEVEL OF FATIGUE AND PERFORMANCE DECREMENTS. A LEVEL OF 50 MMHG OR AN INCREASE OF +2 GZ IN THE UPRIGHT SEAT WAS THE MAXIMUM AGSM RECOMMENDED FOR ROUTINE USE AS AN ANTI-G METHOD FOR OPERATIONAL FIGHTER PILOTS.

ACCESSION NUMBER: 204  
AD: A  
AD NUMBER: 093229  
SOURCE NAME: SCHOOL OF AEROSPACE MEDICINE BROOKS AFB, TX

TITLE: HUMAN RESPONSES TO REPEATED HIGH G SIMULATED AERIAL COMBAT MANEUVERS

PERSONAL AUTHORS: BURTON, R.R.

REPORT DATE: 80  
PAGINATION: 10P  
REPORT SERIES NUMBER: SAM-TR-80-320  
DIST/AVAIL STATEMENT: PUB. IN AVIAT SPACE ENVIRON MED 51(11):1185-1192 NOV 1980 NLM-81159821 JOURNAL CODE:9JA

ABSTRACT: FIVE SUBJECTS WEARING STANDARD USAF ANTI-G SUITS AND SEATED AT A 65 DEGREE BACK ANGLE WERE EXPOSED TO A SIMULATED AERIAL COMBAT MANEUVER (SACM) WHICH WAS REPEATED 5 TIMES WITH 4-MIN 1-G RESTS BETWEEN EACH SACM EXPOSURE. THE SACM WAS 122 S IN DURATION WITH 10 S ACCELERATION PEAKS AT 4 G FOR 15 S. THIS SERIES OF REPEATED SACM EXPOSURE FATIGUED FOUR OF THE FIVE SUBJECTS. HEART RATE AND RHYTHM, ARTERIAL OXYGEN SATURATION, EXPIRED GASES, LACTATE, PYRUVATE, GLUCOSE, CPK ENZYMES AND ISOENZYMES, BLOOD VOLUME,

SUBJECTIVE FATIGUE MEASUREMENTS, AND SUBJECT PERFORMANCE WERE EXAMINED RELATIVE TO THE DEVELOPMENT OF FATIGUE, THE ENERGY COST OF THE M-1, AND TOLERANCE TO THE SACM. ALL PHYSIOLOGIC-METABOLIC PARAMETERS WERE SIGNIFICANTLY AFFECTED BY REPEATED SACMS, HOWEVER, ONLY HEART RATE CHANGES APPEARED TO BE CORRELATED WITH DEVELOPING FATIGUE. A SIGNIFICANT AMOUNT OF ENERGY IS REQUIRED TO PERFORM THE M-1. SUBJECTS WHOSE ENERGY-METABOLIC AND CARDIOVASCULAR STATES ARE LEAST DISTURBED BY HIGH G EXPOSURE ARE THOSE PERSONS WHO WILL PERFORM BEST AND BECOME LEAST FATIGUED DURING REPEATED AERIAL COMBAT MANEUVERS.

ACCESSION NUMBER: 243  
AD: A  
AD NUMBER: 087613  
SOURCE NAME: SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TX  
  
TITLE: HUMAN TOLERANCE TO AERIAL COMBAT MANEUVERS,  
  
PERSONAL AUTHORS: BURTON, R.R., AND SHAFFSTALL, R.M.  
  
REPORT DATE: 80  
PAGINATION: 10P  
REPORT SERIES NUMBER: SAM-TR-80-217  
SUPPLEMENTARY NOTE: PRESENTED AT THE 1978 AEROSPACE MEDICAL ASSOCIATION ANNUAL MEETING  
  
DIST/AVAIL STATEMENT: PUB. IN AVIATION SPACE AND ENVIRONMENTAL MEDICINE, V51 N7 P641-648 JUL 1980. NLM-81020848 JOURNAL CODE:9JA

ABSTRACT: AN ACCELERATION PROFILE WAS DEVELOPED ON THE USAF SCHOOL OF AEROSPACE MEDICINE'S 6.1-M RADIUS CENTRIFUGE TO MEASURE HUMAN TOLERANCE TO THE AERIAL COMBAT MANEUVER (ACM). THE ACM PROFILE IS A CONTINUOUS REPETITIVE, 4.5 GZ FOR 15 S TO 7 GZ FOR 15 S, CYCLIC G EXPOSURE WHICH IS TERMINATED BY THE SUBJECT AT HIS FATIGUE ENDPOINT. ACM TOLERANCE USING THIS TYPE OF G PROFILE WERE DETERMINED FOR SEVEN SUBJECTS AT FOUR DIFFERENT SEATBACK ANGLES; I.E., 13, 30, 55, AND 65 DEGREES FROM THE VERTICAL. GROUP (MEAN+/-S.E.) TOLERANCE FOR THE ACM WERE 170+/- 17 S AT 13 DEGREES AND 541+/- 48 S AT 65 DEGREES. THESE TOLERANCES WERE NOT USUALLY CORRELATED WITH RELAXED GRADUAL ONSET G TOLERANCES. THE SUBJECTIVE FATIGUE ENDPOINT WAS PHYSIOLOGICALLY VERIFIED USING HEART RATE, HEART RHYTHM, AND PERFORMANCE CRITERIA AT THE FOUR SEATBACK ANGLES. THE POTENTIAL VALUE OF THE ACM PROFILE IS CONSIDERED AS A MEASURE OF THE EFFECTIVENESS OF ANTI-G EQUIPMENT AND METHODS IN THE AERIAL COMBAT ENVIRONMENT.

ACCESSION NUMBER: 837  
AD: A  
AD NUMBER: 000430  
SOURCE NAME: SCHOOL OF AEROSPACE MEDICINE BROOKS AFB, TX  
  
TITLE: MAN AT HIGH SUSTAINED +GZ ACCELERATION: A REVIEW.  
  
PERSONAL AUTHORS: BURTON, R.R., LEVERETT, S.D., JR., AND MICHAELSON, E.D.

REPORT DATE: 74  
PAGINATION: 25P  
REPORT SERIES NUMBER: SAM-TR-74-333; AGARD-AG-190

DIST/AVAIL STATEMENT: PUB. IN AEROSPACE MEDICINE, V45 N10 P1115-1136 1974.  
NLM-77181276 ALSO PUB. AS AGARDOGRAPH NO 190  
(AGARD-AG-190) ON MAN AT HIGH SUSTAINED +GZ  
ACCELERATION, MARCH 1974. NLM-8209105

ABSTRACT: THE PHYSIOLOGY AND PATHOPHYSIOLOGY OF +GZ EXPOSURE OF  
MAN TO +6 GZ AND ABOVE FOR PERIODS LONGER THAN 15 SECONDS--TERMED HIGH  
SUSTAINED G (HSG)--ARE CONSIDERED IN SOME DETAIL. THE INCREASE IN GZ  
TOLERANCE AFFORDED BY SEVERAL (A) MECHANICAL AIDS AND/OR (B) CONSCIOUS  
PHYSIOLOGIC BASED COUNTERMEASURES IS DISCUSSED AND THE RELATIVE LITERATURE IS  
REVIEWED. THE PRINCIPAL LIMITATIONS OF HUMAN TOLERANCE TO HSG APPEAR TO BE  
THE OCCURRENCE OF BLACKOUT OR FATIGUE.

ACCESSION NUMBER: 732  
AD: A  
AD NUMBER: 013707  
SOURCE NAME: SCHOOL OF AEROSPACE MEDICINE BROOKS AFB, TX

TITLE: THE PHYSIOLOGIC EFFECTS OF SEATBACK ANGLES < 45 DEG  
(FROM THE VERTICAL) RELATIVE TO G.

PERSONAL AUTHORS: BURTON, R.R., IAPIETRO, P.F., AND LEVERETT, S.D., JR

REPORT DATE: 75  
PAGINATION: 13P  
REPORT SERIES NUMBER: SAM-TR-75-257  
DIST/AVAIL STATEMENT: PUB. IN AVIATION, SPACE AND ENVIRONMENTAL MEDICINE,  
P887-897 JUL 75. NLM-75224430 JOURNAL CODE:9JA

ABSTRACT: SEAT BACK ANGLES OF 13 DEG, 18 DEG, AND 30 DEG FROM  
THE VERTICAL ARE FOUND RESPECTIVELY IN THE F-15, YF-17, AND YF-16 FIGHTER  
AIRCRAFT. THEORETICALLY, THE REASONS FOR THE DEPARTURE FROM THE STANDARD 13  
DEG SEAT BY THE YF-16 AND 17 ARE INCREASES IN PILOT COMFORT, TARGET  
VISIBILITY, PERFORMANCE, AND G TOLERANCE. THE FOLLOWING OBJECTIVE AND  
SUBJECTIVE PHYSIOLOGIC PARAMETERS WERE EXAMINED RELATIVE TO SEAT BACK ANGLES  
OF 23 DEG, 28 DEG, AND 40 DEG (SEAT ANGLE +10 DEG ANGLE OF ATTACK); HEART RATE  
AND RHYTHM; ARTERIAL OXYGEN SATURATION; PERFORMANCE; INTRATHORACIC  
(ESOPHAGEAL) PRESSURE; ARTERIAL PRESSURE; AND, SUBJECT EVALUATION OF COMFORT,  
EFFORT, AND FATIGUE. EIGHT EXPERIMENTAL SUBJECTS FROM THE USAF SCHOOL OF  
AEROSPACE MEDICINE (SAM) AND FOUR YF-16/17 TEST PILOTS WERE EXPOSED TO A  
SIMULATED AERIAL COMBAT MANEUVER (SACM) WHICH INCLUDED 12 S OF 8 GZ. RELAXED  
AND STRAINING HIGH SUSTAINED G (HSG) TOLERANCES (6 GZ FOR 60 S) WERE ALSO  
DETERMINED USING ONLY SAM SUBJECTS. THE ADVANTAGES OF THE 30 DEG SEATBACK  
ANGLE DURING THE SACM INCLUDED INCREASED SUBJECT COMFORT, LESS FATIGUE AND  
EFFORT, A STATISTICALLY SIGNIFICANT REDUCTION IN THE INCREASED MEAN HEART RATE  
ASSOCIATED WITH G EXPOSURE, AND GREATER PILOT ACCEPTANCE. ON THE OTHER HAND,  
A STATISTICALLY SIGNIFICANT REDUCTION IN ARTERIAL OXYGEN SATURATION WAS FOUND  
DURING THE SACM AT 40 DEG COMPARED WITH THE 23 DEG BACK ANGLE ALTHOUGH THIS  
SEAT BACK ANGLE DIFFERENCE WAS NOT FOUND DURING THE HSG EXPOSURES. AN

INCREASE IN RELAXED G TOLERANCE WAS FOUND WITH THE 40 DEG SEAT BACK ANGLE--  
STATISTICALLY SIGNIFICANT ONLY COMPARED WITH THE 28 DEG SEATBACK ANGLE.

ACCESSION NUMBER: 44821  
SOURCE NAME: BIODYNAMICS BRANCH, USAF SCHOOL OF AEROSPACE  
MEDICINE, BROOKS AFB, TX

TITLE: PHYSIOLOGIC RESPONSE TO REPEATED HIGH G SIMULATED  
AERIAL COMBAT MANEUVERS

PERSONAL AUTHORS: BURTON, R.R.  
REPORT DATE: 77/09/15  
PAGINATION: 1P  
DIST/AVAIL STATEMENT: PUBLISHED AND PRESENTED AT REVIEW OF AIR FORCE  
SPONSORED BASIC RESEARCH IN ENVIRONMENTAL AND  
ACCELERATION PHYSIOLOGY, 15-16 SEP 77, UNIVERSITY OF  
TEXAS MEDICAL BRANCH AT GALVESTON, P11, (ACCESS NO.  
44813).

ABSTRACT: PILOTS FLYING HIGH PERFORMANCE AIRCRAFT (E.G., F-14,  
F-15, AND F-16) WILL BE EXPOSED TO FREQUENT, OFTEN REPEATED, HIGH G AERIAL  
COMBAT MANEUVERS. ALTHOUGH, THE PHYSIOLOGIC RESPONSE OF A SINGLE EPISODE OF  
HIGH SUSTAINED G HAS BEEN DETERMINED, LITTLE IS KNOWN ABOUT THE EFFECTS OF  
REPEATED HIGH G EXPOSURES. CONSEQUENTLY, FIVE SUBJECTS WERE EXPOSED TO FIVE  
REPEATED SIMULATED AERIAL COMBAT MANEUVERS (SACMS) USING THE HUMAN CENTRIFUGE  
AT THE USAF SCHOOL OF AEROSPACE MEDICINE.

ACCESSION NUMBER: 48651  
SOURCE NAME: CENTRE D'ESSAIS EN VOL, ISTRES, FRANCE

TITLE: CHOICE OF SEAT BACK ANGLE TO IMPROVE ACCELERATION  
TOLERANCE

PERSONAL AUTHORS: CLERE, J.M., VIEILLEFOND, H., AND POIRIER, J.L.

REPORT DATE: 85/10  
PAGINATION: 51P  
REPORT SERIES NUMBER: CEV-70-209, ESA-86-97195  
DIST/AVAIL STATEMENT: N86-29512

ABSTRACT: THE OPTIMIZATION OF PILOT SEAT BACK ANGLE AT  
ACCELERATIONS OF +7.8 TO 9GZ WERE STUDIED USING CENTRIFUGAL SIMULATION  
FACILITIES. THE PHYSIOLOGICAL PARAMETERS SUCH AS HEART RATE, BLOOD PRESSURE,  
AND VISUAL FIELD WERE MEASURED AT SEAT BACK ANGLES FROM 30 TO 60 DEG. IT IS  
SHOWN THAT THE SEAT BACK ANGLE OF 60 DEG ELIMINATES VISUAL PROBLEMS AT +9 GZ  
AND PROTECTS AGAINST BLOOD CIRCULATION PROBLEMS. ANGLES OF 30 DEG PRODUCE  
CLEAR INTOLERANCE SYMPTOMS.

ACCESSION NUMBER: 12140  
SOURCE NAME: NASA-AMES RESEARCH CENTER, MOFFETT FIELD, CA

**TITLE:** COMBINING TECHNIQUES TO ENHANCE PROTECTION AGAINST  
HIGH SUSTAINED ACCELERATIVE FORCES.

**PERSONAL AUTHORS:** COHEN, M.M.

**REPORT DATE:** 83/04

**DIST/AVAIL STATEMENT:** NLM-83203918 AVIAT SPACE ENVIRON 54 (4 ) P338-42 1983  
APR JOURNAL CODE:9JA

**ABSTRACT:** FIVE VOLUNTEER SUBJECTS WERE TESTED FOR ACCELERATION TOLERANCE UNDER EIGHT DIFFERENT EXPERIMENTAL CONDITIONS REPRESENTING RELAXED AND UNPROTECTED TOLERANCE AND TOLERANCE WITH ALL POSSIBLE COMBINATIONS OF THE ANTI-G SUIT, THE M-1 MANEUVER, AND SUPINATION IN A PALE SEAT. THE INDIVIDUAL AND COMBINED EFFECTS OF THE VARIOUS ACCELERATION PROTECTIVE TECHNIQUES WERE EXAMINED AS THEY RELATED TO VARIOUS MODELS FOR ACCELERATION PROTECTION, AND THE DATA REVEALED NO STATISTICALLY SIGNIFICANT DEVIATIONS FROM A SIMPLE ADDITIVE MODEL. THE APPARENT NET ADDITIVITY WAS INTERPRETED AS RESULTING FROM A COMBINATION OF ADDITIVE, SYNERGISTIC, AND OVERLAPPING MECHANISMS.

**ACCESSION NUMBER:** 7682

**SOURCE NAME:** ADVISORY GROUP FOR AEROSPACE RESEARCH AND  
DEVELOPMENT, PARIS (FRANCE)

**TITLE:** EFFECT OF POSTURE ON TOLERANCE TO POSITIVE (+ GZ)  
ACCELERATION

**PERSONAL AUTHORS:** CROSSLEY, R.J., AND GLAISTER, D.H.

**REPORT DATE:** 70/09

**PAGINATION:** 8P

**REPORT SERIES NUMBER:** AGARD-CP-82-71

**ABSTRACT:** THE EFFECT OF VARYING THE POSTURE OF EIGHT SUBJECTS ON THEIR RELAXED GREYOUT THRESHOLDS HAS BEEN STUDIED. SIX ANGLES OF THE SEAT BACK BETWEEN 70 DEGREES TO THE HORIZONTAL AND 15 DEGREES, AND RATES OF ONSET OF ACCELERATION OF 1.0 G/SEC AND 0.1 G/SEC WERE USED. THE G THRESHOLDS OF ALL SUBJECTS, WITH BOTH RATES OF ONSET, INCREASED AS THE BACK ANGLE DECREASED AND WERE DIRECTLY PROPORTIONAL TO THE RECIPROCAL OF THE VERTICAL DISTANCE BETWEEN THE EYE AND THE HEMODYNAMIC INDIFFERENCE POINT. THE DEGREE OF NECK FLEXION WAS OBSERVED TO HAVE LITTLE EFFECT ON THE THRESHOLDS AT ANY ONE ANGLE. FOUR SUBJECTS ALSO WORE AN ANTI-G SUIT FOR FURTHER THRESHOLD DETERMINATIONS WITH SEAT BACK ANGLES OF 70 DEGREES, 30 DEGREES AND 15 DEGREES. THE INCREASE IN THRESHOLDS PRODUCED BY THE ANTI-G SUIT WAS THE SAME FOR EACH ANGLE. COMPARISON OF THE THRESHOLD OBSERVED WITH THE TWO RATES OF ONSET SHOW THAT THE 0.1 G/SEC RATE LEADS TO HIGHER THRESHOLDS THAN THE 1.0 G/SEC RATE. THESE STUDIES LEAD US TO BELIEVE THAT A NEAR-SUPINE POSTURE COMBINED WITH AN ANTI-G SUIT CAN PROVIDE RELAXED G THRESHOLDS IN THE REGION OF +6 TO 8 GZ WHILE PERMITTING ADEQUATE FORWARD VISION. SUCH A POSTURE WOULD HAVE THE ADDED ADVANTAGE OF EXPOSING THE AIRCREW TO + GX ACCELERATION DURING EJECTION.

**ACCESSION NUMBER:** 3232

**AD NUMBER:** 098515



SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER JOHNSVILLE, PA, AVIATION MEDICAL ACCELERATION LAB

TITLE: THE EFFECT OF PARTIAL SUPINATION COMBINED WITH THE ANTI-G SUIT ON G TOLERANCE IN NAVY PILOTS

PERSONAL AUTHORS: DORMAN, P.J.

REPORT DATE: 56/05/08

PAGINATION: 1 VOLUME

REPORT SERIES NUMBER: NADC-MA-5606

SUPPLEMENTARY NOTE: ARTICLE TITLE IN AVIATION MEDICINE: EFFECT ON G TOLERANCE OF PARTIAL SUPINATION COMBINED WITH THE ANTI-G SUIT

DIST/AVAIL STATEMENT: AVIATION MEDICINE PP490-496, DECEMBER 1956

ABSTRACT: A TOTAL OF 305 RUNS ON 9 TRAINED CENTRIFUGE SUBJECTS AND 233 RUNS ON 24 NAVY PILOTS WERE PERFORMED. USING GRAYOUT AS AN ENDPOINT, 66.7% OF THE FLEET PILOTS WERE ABLE TO WITHSTAND +7 GZ FOR 15 TO 30 SEC SITTING UPRIGHT, WEARING A STANDARD NAVY Z-2 SUIT INFLATED TO 7-9 PSI PRESSURE. THE REMAINDER FAILED THE 7 G 30 SEC RUN. THE 65 DEGREE SUPINE POSITION ALONE FAILED TO IMPROVE THE PERFORMANCE OF THIS LATTER GROUP. ALL OF THESE SUBJECTS WERE THEN RETESTED IN THE 65 DEGREE SUPINE POSITION WEARING AN INFLATED Z-2 SUIT. 100% OF SUBJECTS THUS TESTED SUCCESSFULLY WITHSTOOD +7 GZ FOR 30 SECONDS, ALTHOUGH THE UNPROTECTED TOLERANCE IN SOME SUBJECTS WAS AS LOW AS +2.5 GZ.

ACCESSION NUMBER: 4799

AD NUMBER: 760814

SOURCE NAME: AEROSPACE MEDICAL RESEARCH LAB, WRIGHT-PATTERSON AFB, OHIO

TITLE: PERFORMANCE OF THE ANTI-G VALVE WHEN SUBJECTED TO VARYING LATERAL FORCES

PERSONAL AUTHORS: FRAZIER, J.W., WHITNEY, R.U., AND ASHARE, A.B.

REPORT DATE: 73/02

PAGINATION: 11P

REPORT SERIES NUMBER: AMRL-TR-72-67

ABSTRACT: HUMAN SUBJECTS ON THE DYNAMIC ENVIRONMENT SIMULATOR (DES) WERE EXPOSED TO LEVELS OF 4, 5, 6, AND +7 GZ IN A VARIABLE BACK ANGLE SEAT. A STANDARD G VALVE (MIL-V-9370D) MOUNTED ON THE SEAT BACK PAN WAS USED TO FURNISH G-SUIT PRESSURE. THE SEAT BACK ANGLE, AND HENCE THE G-VALVE, WAS RUN AT ANGLES OF 30, 45, 55, AND 65 DEGREES TO THE RESULTANT FORCE VECTOR. ALTHOUGH THE OPENING POINTS AND SUIT PRESSURES ARE ALTERED, THE G-VALVE FUNCTIONS IN A REPRODUCIBLE AND USABLE MANNER. PRESSURE CURVES AND SUBJECT RESPONSES ARE REPORTED.

ACCESSION NUMBER: NA

SOURCE NAME: AEROSPACE MEDICINE 45(7):755-757

**TITLE:** G SUIT FILLING PRESSURES DETERMINED BY  
SEAT BACK ANGLE

**PERSONAL AUTHORS:** FRAZIER, J.W., WHITNEY, R.U., ASHARE, A.B., ROGERS,  
D.B., AND SKOWRONSKI, V.D.

**REPORT DATE:** 74/07  
**PAGINATION:** 3  
**SUPPLEMENTARY NOTE:** JOURNAL ARTICLE  
**DIST/AVAIL STATEMENT:** FROM SOURCE

**ABSTRACT:** THIS STUDY CONCLUDED THAT ANTI-G SUIT FILLING  
PRESSURES CAN BE SIGNIFICANTLY REDUCED AS THE SEAT CONFIGURATION BE-  
COMES MORE SUPINE. MAXIMUM SEAT BACK ANGLE STUDIED WAS 65°

**ACCESSION NUMBER:** 4447  
**AD:** A  
**AD NUMBER:** 025784  
**SOURCE NAME:** AEROSPACE MEDICAL RESEARCH LAB WRIGHT-PATTERSON AFB,  
OHIO

**TITLE:** TEST PILOT EVALUATION OF A RECLINED COCKPIT SEAT AS  
AN AID TO G TOLERANCE AND PERFORMANCE.

**PERSONAL AUTHORS:** FRAZIER, J.W., AND MCELREATH, K.W.

**REPORT DATE:** 76/01  
**PAGINATION:** 22P  
**REPORT SERIES NUMBER:** AMRL-TR-75-73

**ABSTRACT:** TWENTY-TWO STUDENT TEST PILOTS HAVE PARTICIPATED IN  
CLOSED-LOOP TRACKING INDOCTRINATION RUNS ON THE DYNAMIC ENVIRONMENT SIMULATOR.  
EACH PILOT FLEW THROUGH A SERIES OF PROFILES UP TO 6 GZ IN BOTH THE  
CONVENTIONAL UPRIGHT SEAT POSITION AND A 55 DEGREES TILT BACK SEAT POSITION.  
THE SUBJECTIVE RESPONSES AND PILOT QUESTIONNAIRES ARE PRESENTED.

**ACCESSION NUMBER:** 3263  
**AD NUMBER:** 036856  
**SOURCE NAME:** NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA, AVIATION  
MEDICAL ACCELERATION LAB

**TITLE:** PHYSIOLOGICAL INVESTIGATION OF INCREASING RESISTANCE  
TO BLACKOUT BY PROGRESSIVE BACKWARD TILTING TO THE  
SUPINE POSITION

**PERSONAL AUTHORS:** GELL, C.F., AND HUNTER, H.N.

**REPORT DATE:** 54/06/30  
**PAGINATION:** 1 VOLUME  
**REPORT SERIES NUMBER:** NADC-MA-5406  
**DIST/AVAIL STATEMENT:** PUB. IN AVIATION MEDICINE P568-577 DECEMBER 1954

**ABSTRACT:** A HEALTHY MALE SUBJECT CAN TOLERATE 15 TRANSVERSE G WHILE SUPINATED AT 85 DEGREES FOR FIVE SECONDS WITH NO INDICATION OF IMPENDING BLACKOUT. AT 77 DEGREES BACKWARD TILT, THE ANTI-BLACKOUT PROTECTION DOES NOT EXCEED THAT PROTECTION AFFORDED BY AN INFLATED ANTI-G SUIT WITH THE SUBJECT IN THE UPRIGHT SEATED POSITION. TO INSURE FULL PROTECTION AGAINST BLACKOUT THE SUBJECT MUST BE SUPINATED BEYOND 77 DEGREES BACKWARD TILT.

**ACCESSION NUMBER:** 46670  
**SOURCE NAME:** ROYAL AIR FORCE INSTITUTE OF AVIATION MEDICINE,  
FARNBOROUGH, HAMPSHIRE, U.K.

**TITLE:** CENTRIFUGE ASSESSMENT OF A RECLINING SEAT

**PERSONAL AUTHORS:** GLAISTER, D.H., AND LISHER, B.J.

**REPORT DATE:** 76/10  
**PAGINATION:** 8P  
**REPORT SERIES NUMBER:** AGARD-CP-189  
**DIST/AVAIL STATEMENT:** PUB. IN AGARD CONFERENCE PROCEEDINGS NO. 189  
PATHOPHYSIOLOGY OF HIGH SUSTAINED +GZ ACCELERATION,  
AIR COMBAT MANEUVERING, USE OF CENTRIFUGES IN  
PERFORMANCE TRAINING (ACCESS NO 7485) PP A4-1 - A4-8

**ABSTRACT:** A RECLINING SEAT HAS BEEN BUILT WHICH WOULD GIVE A PILOT A SIGNIFICANT INCREASE IN ACCELERATION TOLERANCE WHILST MAINTAINING ADEQUATE FORWARD VISION. THE EFFECT OF ANTI-G SUIT INFLATION HAS BEEN INVESTIGATED USING THREE DIFFERENT PRESSURE REGIMENS, AND POSITIVE PRESSURE BREATHING (PPB) HAS BEEN USED TO COUNTER THE ADDED INSPIRATORY EFFORT WHICH RESULTED FROM THE CONSIDERABLE +GX ACCELERATION VECTOR. THE RECLINING SEAT ALONE GAVE AN INCREASE IN TOLERANCE OF 1.4G WHEN COMPARED WITH A CONVENTIONAL SEAT; ANTI-G SUIT INFLATION AFFORDED A FURTHER 1.0 TO 1.6G; AND PPB A FURTHER 1.0G. THE COMBINATION LED TO RELAXED GREYOUT THRESHOLDS WHICH AVERAGED 7.4G (RANGE 6.0 TO 8.6G) IN 9 SUBJECTS. PPB PRODUCED A SIGNIFICANT INCREASE IN VITAL CAPACITY AND RESTORED THE EXPIRATORY RESERVE VOLUME TO NEAR NORMAL LEVELS. SUBJECTIVELY, BREATHING BECAME MUCH EASIER. THE CLOSING VOLUME OF THE LUNG WAS INCREASED BY ACCELERATION, BUT WAS NOT SIGNIFICANTLY AFFECTED BY PPB. HOWEVER, THE INCREASE IN EXPIRATORY VOLUME WITH PPB SHOULD LEAD TO LESS AIRWAY CLOSURE DURING TIDAL BREATHING, WITH A CONSEQUENT INCREASE IN ARTERIAL OXYGEN LEVELS AND A DECREASED SUSCEPTIBILITY TO ACCELERATION ATELECTASIS. IT IS CONSIDERED THAT A SEAT IN WHICH A NEAR SUPINE POSITION IS ADOPTED WITH RESPECT TO THE G VECTOR, WHEN USED IN CONJUNCTION WITH AN ANTI-G SUIT AND POSITIVE PRESSURE BREATHING, WILL RESULT IN A G TOLERANCE WHICH IS IN MORE ACCORD WITH THE PERFORMANCE OF MODERN MILITARY AIRCRAFT.

**ACCESSION NUMBER:** 47461  
**SOURCE NAME:** PROCEEDINGS OF THE 4TH ANNUAL INTERNATIONAL CONFERENCE  
ON AVIATION PHYSIOLOGY SPONSORED BY THE AEROMEDICAL &  
TRAINING INSTITUTE DIV., ENVIRONMENTAL TECTONICS  
CORP., COUNTY LINE INDUSTRIAL PARK, SOUTHAMPTON, PA  
18966

**TITLE:** EFFECTS OF SUSTAINED ACCELERATION ON THE CIRCULATION

PERSONAL AUTHORS: GLAISTER, D.H.

REPORT DATE: 85/10/11

PAGINATION: 12P

SUPPLEMENTARY NOTE: PRESENTED PAPER

DIST/AVAIL STATEMENT: PUB IN AVIATION MEDICINE, ARTICLES FROM THE BRITISH MED. JOURNAL, P38-47, 1983-ALSO AVAILABLE FROM SOURCE

ABSTRACT: THE EFFECTS OF SUSTAINED ACCELERATION ON THE CIRCULATION WILL COVER THE FOLLOWING TOPICS: THE DEFINITION OF G AND ITS VECTORS; HYDROSTATIC PRESSURE GRADIENTS AND THE CONCEPT OF A LEVEL OF HYDROSTATIC INDIFFERENCE; BLOOD POOLING AND TRANSUDATION; REDUCED VENOUS RETURN AND CARDIAC OUTPUT; THE APPLICATION OF STARLING RESISTOR THEORY TO THE CEREBRAL CIRCULATION AND LOSS OF CONSCIOUSNESS; THE RETINAL CIRCULATION, GREYOUT AND BLACKOUT; PHYSIOLOGICAL COMPENSATORY MECHANISMS AND DISTRIBUTION OF CARDIAC OUTPUT; PRINCIPLES OF PROTECTION AGAINST +GZ ACCELERATION (ANTI-G SUIT, BREATHING MANEUVERS, POSITIVE PRESSURE BREATHING, RECLINING SEAT); SUSTAINED ACCELERATION TOLERANCE LIMITS.

ACCESSION NUMBER: 45117

AD: B

AD NUMBER: 034785

SOURCE NAME: FLYING PERSONNEL RESEARCH COMMITTEE, RAAF INSTITUTE OF AVIATION MEDICINE, FARNBOROUGH, HANTS, ENGLAND

TITLE: THE INFLUENCE OF SEAT BACK ANGLE ON ACCELERATION TOLERANCE

PERSONAL AUTHORS: GLAISTER, D.H.

REPORT DATE: 78/03/11

PAGINATION: 20P

REPORT SERIES NUMBER: FPRC-1365

ABSTRACT: BEST FIT REGRESSIONS PREDICTED THAT IN ORDER TO INCREASE GREYOUT TOLERANCE BY 1 G FROM THAT OBTAINED IN A CONVENTIONAL UPRIGHT SEAT, A BACK ANGLE OF 58 DEG WOULD BE REQUIRED, WHILST INCREMENTS OF 2 AND 3 GZ WOULD REQUIRE ANGLES OF 69 AND 74 DEG RESPECTIVELY. AN ANTI-G SUIT WAS FOUND TO GIVE AN INCREASE IN GREYOUT TOLERANCE OF 1.21 GZ AND FULL PROTECTION OF 3.15 GZ INDEPENDENT OF BACK ANGLE.

ACCESSION NUMBER: 7950

AD: A

AD NUMBER: 114652

SOURCE NAME: AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE, NADC, WARMINSTER, PA

TITLE: PULMONARY FUNCTION MEASURES BEFORE AND AFTER EXPOSURE OF HUMAN SUBJECTS TO + GZ AND +GX ACCELERATION LOADS

PERSONAL AUTHORS: HENDLER, E.

REPORT DATE: 81/09/28

PAGINATION: 22P

REPORT SERIES NUMBER: NADC-81236-60

ABSTRACT: BASELINE DYNAMIC LUNG VOLUME MEASUREMENTS WERE DETERMINED ON FOUR SUBJECTS SEATED UPRIGHT OR RECLINED, BOTH WITH AND WITHOUT INFLATION OF AN ANTI-G SUIT (AGS). ADDITIONAL MEASUREMENTS WERE MADE BEFORE AND AFTER EXPOSING THE SUBJECTS TO DOUBLE ACCELERATION PULSES USING THE NADC DYNAMIC FLIGHT SIMULATOR. DURING THE ACCELERATION EXPOSURES, THE SUBJECTS WERE EITHER SEATED UPRIGHT OR WERE RECLINED; THEY WORE AN INFLATED AGS AND EITHER DID OR DID NOT PERFORM THE M-1 MANEUVER. ACCELERATION PULSES LASTED 20 OR 40 S, AND RANGED IN MAGNITUDE FROM +3 TO 7 GZ. THE EFFECTS OF BODY POSITION, G-PROTECTIVE CLOTHING, AND ACCELERATION EXPOSURE ON PULMONARY FUNCTION MEASURES DERIVED FROM FLOW-VOLUME LOOPS ARE DESCRIBED.

ACCESSION NUMBER: NA  
SOURCE NAME: AEROSPACE MEDICAL RESEARCH LABORATORY,  
WRIGHT PATTERSON AFB, OH 45433-6573

TITLE: EVALUATION OF ARTERIAL OXYGEN CONCENTRATION IN HUMANS  
EXPOSED TO GZ GX ACCELERATION FORCES

PERSONAL AUTHORS: HOLDEN, F.M., AND ROGERS, D.B.

REPORT DATE: 73/11  
REPORT SERIES NUMBER: AMRL-TR-73-81  
SUPPLEMENTARY NOTE: TECHNICAL REPORT  
DIST/AVAIL STATEMENT: AVAILABLE FROM DTIC OR NTIS-IDENTIFICATION NUMBERS NOT  
KNOWN

ABSTRACT: REPORTS DEVELOPMENT OF A MATHEMATICAL MODEL RELATING  
POSTURE TO ARTERIAL OXYGEN CONCENTRATION.

ACCESSION NUMBER: NA  
SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE, PA

TITLE: PILOT SUPINATION IN HIGH PERFORMANCE AIRCRAFT IS BOTH  
ESSENTIAL AND ACHIEVABLE

PERSONAL AUTHORS: HORAN, J.J.

REPORT DATE: 74/09  
PAGINATION:  
REPORT SERIES NUMBER: NADC-74204-40  
SUPPLEMENTARY NOTE: TECHNICAL REPORT  
DIST/AVAIL STATEMENT: PROBABLY AVAILABLE FROM BOTH DTIC AND NTIS-NO ID  
NUMBERS FOUND

ABSTRACT: NOT AVAILABLE WHEN ENTERED IN THIS DATABASE

ACCESSION NUMBER: 8110  
SOURCE NAME: PROCEEDINGS OF THE ANNUAL SCIENTIFIC MEETING OF THE  
AEROSPACE MEDICAL ASSOC. MAY 4-7, 1981:209-10

**TITLE:** NECK MUSCLE STRESS INDUCED BY POSTURAL EFFECTS AND VIBRATION OF A SUPINE SEAT

**PERSONAL AUTHORS:** JOHNSON, J.C., AND WELLS, J.H.

**REPORT DATE:** 81/05  
**PAGINATION:** 2P  
**SUPPLEMENTARY NOTE:** PRESENTED PAPER  
**DIST/AVAIL STATEMENT:** AEROSPACE MEDICAL ASSOCIATION  
**ACCESSION NUMBER:** 7540  
**SOURCE NAME:** ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT, FRANCE

**TITLE:** THE EFFECT OF RECLINED SEATING ON THE TRANSMISSION OF LINEAR VIBRATION TO THE HEAD

**PERSONAL AUTHORS:** JOHNSTON, M.E.

**REPORT SERIES NUMBER:** AGARD-CP-267  
**SUPPLEMENTARY NOTE:** IN AGARD CONFERENCE PROCEEDINGS NO. 267 HIGH-SPEED LOW-LEVEL FLIGHT: AIRCREW FACTORS

**ACCESSION NUMBER:** 7996  
**SOURCE NAME:** USAF SCHOOL OF AEROSPACE MEDICINE, BROOKS AFB, TX

**TITLE:** THE USE OF A FIXED BASE SIMULATOR AS A TRAINING DEVICE FOR HIGH SUSTAINED OR ACM (AIR COMBAT MANEUVERING) + GZ STRESS

**PERSONAL AUTHORS:** LEVERETT, S.D., AND BURTON, R.R.

**REPORT DATE:** 76/10  
**PAGINATION:** 5P  
**REPORT SERIES NUMBER:** AGARD-CP-189  
**DIST/AVAIL STATEMENT:** PUB. IN AGARD CONFERENCE PROCEEDINGS NO. 189 PATHOPHYSIOLOGY OF HIGH SUSTAINED +GZ ACCELERATION, AIR COMBAT MANEUVERING, USE OF CENTRIFUGES IN PERFORMANCE TRAINING (ACCESS NO 7485) PP A8-1 - A8-6

**ABSTRACT:** THE USE OF A CENTRIFUGE AS A TRAINING DEVICE TO IMPROVE +GZ TOLERANCE IN 92 EXPERIENCED TACTICAL AIR COMMAND FIGHTER PILOTS IS DESCRIBED.

**ACCESSION NUMBER:** 48743  
**SOURCE NAME:** ROYAL AIR FORCE INSTITUTE OF AVIATION MEDICINE, FARNBOROUGH, HANTS, ENGLAND

**TITLE:** THE PHYSIOLOGY OF HIGH G PROTECTION

**PERSONAL AUTHORS:** LISHER, B.J.

**REPORT DATE:** 76/05  
**PAGINATION:** 2P

REPORT SERIES NUMBER: AGARD  
DIST/AVAIL STATEMENT: PUB. IN AGARD 4TH ADVANCED OPERATIONAL AVIATION  
MEDICINE COURSE, 2PP, 1976

ABSTRACT: CERTAIN OPERATIONS, PARTICULARLY AIR-TO-AIR COMBAT, MAY BE PHYSIOLOGICALLY LIMITED RATHER THAN LIMITED BY AIRCRAFT DESIGN PARAMETERS. AN ACCELERATION LEVEL OF 8G SUSTAINED FOR 60 SECONDS HAS BEEN SUGGESTED AS A POINT TO WHICH ACCELERATION PROTECTION SHOULD BE AIMED, ALTHOUGH HIGHER G LEVELS FOR SHORTER PERIODS OF TIME CAN BE EXPECTED. TWO METHODS OF HIGH G PROTECTION ARE PRESENTED, ONE USING A RECLINING SEAT AND THE OTHER USING IMMERSION OF THE BODY IN WATER.

ACCESSION NUMBER: 10730  
SOURCE NAME: AF AEROSPACE MEDICAL RESEARCH LABORATORY,  
WRIGHT-PATTERSON AFB, OH

TITLE: CARDIAC FUNCTION MONITORED BY IMPEDANCE CARDIOGRAPHY  
DURING CHANGING SEATBACK ANGLES AND ANTI-G SUIT  
INFLATION

PERSONAL AUTHORS: LOGAN, J.S., VEGHTE, J.H., FREY, M.A.B.,  
ROBILLARD, L.M.J., MANN, B.L., AND LUCIANI R.J.

REPORT DATE: 81  
PAGINATION: 25P  
DIST/AVAIL STATEMENT: NLM-83203916; AVIAT SPACE ENVIRON 54(4):328-333 1983  
APR JOURNAL CODE:9JA

ABSTRACT: IMPEDANCE CARDIOGRAPHY (IC) APPEARS TO BE A PROMISING NONINVASIVE TECHNIQUE FOR MONITORING SMALL CHANGES IN PILOT CARDIOVASCULAR STATUS DURING CONDITIONS SIMULATING FLIGHT. HEART RATE (HR), STROKE VOLUME (SV), CARDIAC OUTPUT (CO), VENTRICULAR EJECTION TIME (VET), AND THORACIC IMPEDANCE (ZO) WERE MONITORED IN TEN VOLUNTEERS FOR FIVE MINUTES AT EACH OF FOUR SEATBACK ANGLES FROM VERTICAL: 12, 30, 45, AND 60 DEGREES. DATA WERE ALSO OBTAINED AT THREE SEATBACK ANGLES (12,30,60) FOR SIX MINUTES EACH PRIOR TO, DURING, AND AFTER INFLATION OF THE STANDARD USAF ANTI-G SUIT TO 1.5 PSI. SIGNIFICANT DIFFERENCES ( $P < 0.05$ ) IN HR, SV, CO, VET, AND ZO WERE OBSERVED AMONG THE FOUR POSITIONS. INFLATION OF THE STANDARD ANTI-G SUIT TO 1.5 PSI AT 1.0 +GZ DOES NOT SIGNIFICANTLY ALTER HR, SV, OR CO; WHEREAS SUBSEQUENT DEFLATION OF THE ANTI-G SUIT DOES SIGNIFICANTLY ALTER HR, SV, CO WHEN COMPARED TO INFLATION VALUES. THE RESULTS SUGGEST IC CAN DETECT SMALL DIFFERENCES IN CENTRAL CARDIAC PARAMETERS WITHIN SUBJECTS AS A FUNCTION OF MINOR CHANGES IN BODY POSITION.

ACCESSION NO: 7791  
SOURCE: AEROMEDICAL LABORATORY, AIR MATERIEL COMMAND, WRIGHT  
PATTERSON AFB, OH

TITLE: CREASING TOLERANCE TO ACCELERATION

PERSONAL AUTHORS: MARTIN, E., AND HENRY, J.

REPORT SERIES NUMBER: AF-TR-6025

**ABSTRACT:** A NEW SUPINE HAMMOCK SEAT IS DESCRIBED AS A METHOD FOR ENHANCING TOLERANCE TO POSITIVE ACCELERATION. THE PROTECTION AFFORDED BY THE SEAT WHEN USED IN A FIXED POSITION IS COMPARED WITH THE CONVENTIONAL UPRIGHT SEATED POSTURE. PROTECTION AFFORDED IN THE SUPINE SEAT WHILE WEARING A MODIFIED ANTI-G SUIT COMPRESSING THE LEGS ALONE, EXCEEDS THAT PRESENTLY FOUND WHEN USING AN ANTI-G SUIT IN THE UPRIGHT SEATED POSTURE BY APPROXIMATELY 1 GZ.

**ACCESSION NO:** 45913  
**SOURCE:** NAVAL AIR DEVELOPMENT CENTER,  
WARMINSTER, PA

**TITLE:** HYDROSTATICS AND HIGH G SEATS

**PERSONAL AUTHOR:** NELSON, J.G.

**PAGINATION:** 5P  
**SUPPLEMENTARY NOTE:** SUBMITTED FOR ASMA, SPRING 1986, NASHVILLE, TN, COPIES OF BRIEFING VIEWGRAPHS; ABSTRACT ONLY

**ABSTRACT:** INTRODUCTION. A HYDROSTATIC THEORY OF BLACKOUT IS GENERALLY SUPPORTED IN THE ACCELERATION LITERATURE, BUT THERE IS DISAGREEMENT AS TO THE CORRECT ORIGIN IN THE THORAX FOR H, THE HYDROSTATIC DISTANCE TO THE EYE. OUR GOAL WAS TO DETERMINE WHETHER REPRESENTATIVE PUBLISHED DATA WOULD PREFERENTIALLY SUPPORT SOME PARTICULAR ORIGIN FOR H. METHODS. EXPERIMENTS BY BURNS (1975) AND BURNS & WHINNERY (1984) WERE ANALYZED, USING AN EXPLICIT HYDROSTATIC MODEL REQUIRED TO PLACE THE EYE DIRECTLY OVER THE REFERENCE POINT IN THE THORAX, AND T=G-TOLERANCE (TMIN = MINIMUM OF THE FUNCTION). ITERATIVE NON-LINEAR STATISTICAL METHODS, INCLUDING MULTIPLE REGRESSION (BMPD), WERE USED. RESULTS. THE MEAN ACCELERATION TOLERANCES OF THE (1975) STUDY WERE BEST FITTED BY TMIN=3.98, PHI = 13/74 DEGREES, GIVING R SQUARED = .938. FOR THE SAME SEAT, THE (1984) X-RAY DETERMINATION OF H REFERENCED TO THE AORTIC VALVE YIELDS PHI = 12.06 DEGREES. THE DIFFERENCE BETWEEN THESE ESTIMATES OF PHI WAS QUITE NON-SIGNIFICANT. REFERENCING TO THE ARCH OF THE AORTA SIGNIFICANTLY DEGRADES THE FIT. CONCLUSIONS. THE BEST FIT OF THIS RELAXED ACCELERATION TOLERANCE DATA WAS ACHIEVED WITH A SIMPLE (BUT NON-LINEAR) HYDROSTATIC MODEL WHEREIN H WAS REFERENCED TO AORTIC VALVE AND EYE. IN FUTURE STUDIES, THIS DISTANCE (H) SHOULD BE CAREFULLY MEASURED, AND A WIDE AND EQUAL INTERVAL SCALE OF 1/H INVESTIGATED. THE DATA FROM THESE STUDIES SHOULD BE ANALYZED USING THE APPROPRIATE NON-LINEAR STATISTICAL METHODS.

**ACCESSION NUMBER:** 46333  
**SOURCE NAME:** AIRCRAFT AND CREW SYSTEMS TECHNOLOGY DIRECTORATE,  
NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

**TITLE:** HYDROSTATIC THEORY AND G-PROTECTIVE TILTING AIRCREW SEATS

**PERSONAL AUTHORS:** NELSON, J.G.

**REPORT DATE:** 86  
**PAGINATION:** 19P  
**DIST/AVAIL STATEMENT:** PUB. IN AVIAT SPACE ENVIRON MED 57:(IN PRESS)



**ABSTRACT:** A HYDROSTATIC THEORY OF BLACKOUT IS GENERALLY SUPPORTED IN THE ACCELERATION LITERATURE, BUT THERE IS DISAGREEMENT AS TO THE CORRECT ORIGIN IN THE THORAX FOR H, THE HYDROSTATIC DISTANCE TO THE EYE. REANALYSIS FOR PUBLISHED DATA SHOWED THAT A SIMPLE HYDROSTATIC MODEL, WITH H MEASURED FROM THE AORTIC VALVE TO THE EYE, YIELDS AN EXCELLENT FIT. FUTURE STUDIES SHOULD MEASURE H, USE SEAT-BACK ANGLES GIVING EVEN SPACING ON A 1/H SCALE, AND ANALYZE DATA USING THE REQUIRED NON-LINEAR METHODS.

**ACCESSION NUMBER:** NA

**SOURCE NAME:** BER. GES. PHYSIOLOGIE 96:671 (1936-1937)

**TITLE:** DIE BEDEUTUNG DER LAGE FUR DIE VERTRAGLICHKEIT IM ESCHLEUNIGUNGSEINWIRKUNGEN (THE SIGNIFICANCE OF POSITION ON TOLERANCE IN ACCELERATION-INFLUENCE)

**PERSONAL AUTHORS:** RANKE, O.F.

**REPORT DATE:** 36

**PAGINATION:** 1

**SUPPLEMENTARY NOTE:** JOURNAL ARTICLE

**DIST/AVAIL STATEMENT:** POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS

**ABSTRACT:** NO ABSTRACT AVAILABLE WHEN ENTERED IN THIS DATABASE

**ACCESSION NUMBER:** NA

**SOURCE NAME:** LUFTFAHRTMEDIZIN 1937; 2:243-58

**TITLE:** BESCHLEUNIGUNGSWIRKUNG (ACCELERATION EFFECTS)

**PERSONAL AUTHORS:** RANKE, O.F.

**REPORT DATE:** 37

**PAGINATION:** 16

**SUPPLEMENTARY NOTE:** JOURNAL ARTICLE

**DIST/AVAIL STATEMENT:** POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS

**ABSTRACT:** CITED BY WOOD IN 1990 AS RELATED TO THE WORK OF BURHLEN AND WIESEHOFER CONCERNING THE PRE-WAR GERMAN DEVELOPMENT OF A RADICALLY RECLINED SEAT IN WHICH SUBJECTS WERE ABLE TO TOLERATE EXPOSURES OF 8 TO 10G FOR PERIODS OF 10 SEC. ALSO TOLERATED 15G EXPOSURES OF UNSTATED DURATION, BUT AT THAT LEVEL BREATHING WAS NOT POSSIBLE IN THIS SEAT CONFIGURATION.

**ACCESSION NUMBER:** NA

**SOURCE NAME:** ZEITSCHRIFT DES VEREINS DEUTSCHER INGENIEURE; 84:817-26 OCT 26, 1940

**TITLE:** BESCHLEUNIGUNGSFESTIGKEIT DES MENS- CHEN UN FLUGKONSTRUKTIVE MASSNEHMEN ZU IHRER STEIGERUNG (ACCELERATION STRENGTH/TOLERANCE OF HUMANS, AND AIRCRAFT STRUCTURE MEANS FOR ITS ENHANCEMENT)

**PERSONAL AUTHORS:** RUFF, S.

REPORT DATE: 40/10/26  
 PAGINATION: 19  
 SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
 DIST/AVAIL STATEMENT: POSSIBLY AVAILABLE FROM THE LIBRARY OF CONGRESS

ABSTRACT: NO ABSTRACT AVAILABLE WHEN ENTERED IN THIS DATABASE

ACCESSION NUMBER: NA  
 AD NUMBER: 620 273  
 SOURCE NAME: U.S NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FL

TITLE: THE EFFECT OF HIGH ACCELERATION FORCES UPON CERTAIN  
 PHYSIOLOGICAL FACTORS OF HUMAN SUBJECTS PLACED IN A  
 MODIFIED SUPINE POSITION

PERSONAL AUTHORS: STAUFFER, F.R.

REPORT DATE: 49/10  
 SUPPLEMENTARY NOTE: NAVY PROJECT REPORT  
 DIST/AVAIL STATEMENT: DEFENSE TECHNICAL INFORMATION SERVICE, NATIONAL  
 TECHNICAL INFORMATION SERVICE

ABSTRACT: SUBJECTS RETAINED CONSCIOUSNESS, VISION AND VOLUNTARY  
 FINGER MOVEMENTS UP TO +12Gz FOR 5 TO 8 SECONDS. DIFFICULTY/DISCOMFORT IN  
 RESPIRATION WAS EXPERIENCED.

ACCESSION NUMBER: 45311  
 AD NUMBER: 206318  
 SOURCE NAME: FLYING PERSONNEL RESEARCH COMMITTEE, FARNBOROUGH,  
 GREAT BRITAIN

TITLE: AN INVESTIGATION INTO THE EFFECT OF A RECLINING  
 POSTURE ON THE ABILITY TO WITHSTAND HIGH 'G'

PERSONAL AUTHORS: STEWART, W.K.

REPORT DATE: 40  
 PAGINATION: 2P  
 REPORT SERIES NUMBER: FPRC-212

ABSTRACT: WITH A SEATBACK ANGLE OF 45 DEGRESS IT IS CONSIDERED  
 THAT THE AVERAGE FIGHTER PILOT COULD SUSTAIN +6 TO 6.5 GZ WITHOUT IMPAIRMENT  
 OF VISION.

ACCESSION NUMBER: 7880  
 AD: A  
 AD NUMBER: 145439  
 SOURCE NAME: AF AEROSPACE MEDICAL RESEARCH LABORATORY,  
 WRIGHT-PATTERSON AFB, OH

TITLE: THE HIGH ACCELERATION COCKPIT (HAC): A TECHNOLOGY  
 BASE OVERVIEW - 1983

PERSONAL AUTHORS: VAN PATTEN, R.E., JENNINGS, T.J., AND MAXWELL, M.

REPORT DATE: 83/06

PAGINATION: 5P

REPORT SERIES NUMBER: AFAMRL-TR-84-075

SUPPLEMENTARY NOTE: SAFE ASSOCIATION MEETING, 5-8 NOV 83, SAN ANTONIO, TX

DIST/AVAIL STATEMENT: PUB. IN 1983 SAFE ASSOCIATION PROCEEDINGS (ACCESS NO.

10742), P 43-47; ALSO PUB. IN SAFE JOURNAL 14(2):16-21 SUMMER QUARTER 1984

ACCESSION NUMBER: 45811

SOURCE NAME: PROCEEDINGS OF THE 4TH ANNUAL INTERNATIONAL CONFERENCE ON AVIATION PHYSIOLOGY SPONSORED BY THE AEROMEDICAL & TRAINING INSTITUTE DIV. OF ENVIRONMENTAL TECTONICS CORP., COUNTY LINE INDUSTRIAL PARK, SOUTHAMPTON, PA 18966

TITLE: HUMAN FACTORS AND PERFORMANCE ISSUES IN THE DESIGN OF HIGH PERFORMANCE FIGHTER AIRCRAFT COCKPITS

PERSONAL AUTHORS: VAN PATTEN, R.E.

REPORT DATE: 85/10/11

PAGINATION: 12P

SUPPLEMENTARY NOTE: PRESENTED PAPER

ABSTRACT: OVER THE FIRST SEVEN DECADES OF THIS CENTURY, THE COMPLEXITY OF THE AIRCRAFT COCKPIT AND THE LEVEL OF PERFORMANCE OF THE AIRCRAFT HAVE BOTH INCREASED MANY-FOLD. MAN HAS NOT UNDERGONE A CORRESPONDING PERFORMANCE UPGRADE AND THE POINT HAS BEEN REACHED AT WHICH COCKPIT DESIGN WILL HAVE TO ALTER MARKEDLY IN ORDER TO EXPLOIT MAN'S FULL POTENTIAL AS WELL AS THAT OF THE AIRFRAME. THIS PAPER DISCUSSES SPECIFIC PERFORMANCE TASKING IN THE AIR COMBAT ENVIRONMENT, INCLUDING OFFENSIVE/DEFENSIVE MANEUVERING, WEAPON SELECTION/MANAGEMENT, PILOT MOBILITY, VISION, AND SITUATIONAL AWARENESS. PHYSIOLOGICAL EFFECTS OF HIGH ONSET RATE, HIGH SUSTAINED ACCELERATION ARE DISCUSSED WITH RESPECT TO THESE TASKS, INCLUDING A DISCUSSION OF THE INFLUENCE OF TASK DIFFICULTY AND REALISM ON THE ASSESSMENT OF PERFORMANCE. TECHNIQUES FOR THE ENHANCEMENT OF PERFORMANCE ARE DISCUSSED INCLUDING ANTI-G SUITS AND VALVES, POSTURE, PHYSIOLOGICAL SELF-PROTECTION MANEUVERS, POSITIVE PRESSURE BREATHING, AND PHARMACOLOGY. THIS PAPER CONCLUDES WITH A REVIEW AND COMPARISON OF PERFORMANCE WORK DONE IN RADICALLY RECLINED SEATS IN U.S. AND U.K. LABORATORIES.

ACCESSION NUMBER: 7886

SOURCE NAME: CREW SYSTEMS DEPARTMENT, NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

TITLE: ACCELERATION FORCES ON THE HUMAN SUBJECT

PERSONAL AUTHORS: VOGEL, V.M.

REPORT DATE: 80/09

PAGINATION: 11P

DIST/AVAIL STATEMENT: AVIATION, SPACE AND ENVIRONMENTAL MEDICINE 51(9):970-980, SEPTEMBER 1980. NLM-81020918 JOURNAL CODE:9JA

ABSTRACT: AN OVERALL VIEW OF THE METHODOLOGY OF ACCELERATION RESEARCH, I.E., G-TOLERANCE MEASURING DEVICES AND THE PECULIARITIES OF EACH, GENERAL INFORMATION ON G-TOLERANCE AND TYPES OF C STRESS, THE METHODS OF DETERMINING G TOLERANCE, AND THE METHODS OF MODIFYING ONE'S G TOLERANCE IS PRESENTED. SOME HUMAN FACTORS ASPECTS OF G TOLERANCE, AS WELL AS SOME PHYSIOLOGICAL CHANGES UNDER G, I.E., ECG CHANGES, CARDIAC PROBLEMS, AND VARIOUS OTHER BIOCHEMICAL AND HEMATOLOGICAL ALTERATIONS, ARE DISCUSSED. SPECIAL EMPHASIS IS PLACED ON THE PROVEN G-ASSOCIATED CARDIAC PATHOLOGY FOUND IN VARIOUS ANIMAL MODELS, AND ITS POSSIBLE APPLICATION TO THE HUMAN SUBJECT.

ACCESSION NUMBER: 18375

TITLE: COMPARISON OF SEVERAL G-TOLERANCE MEASURING METHODS AT VARIOUS SEATBACK ANGLES

PERSONAL AUTHORS: VOGUE, V.M.

REPORT DATE: 78/02

DIST/AVAIL STATEMENT: NLM-78144151 AVIAT SPACE ENVIRON 49 (2 ) P377-83 1978 FEB JOURNAL CODE:9JA

ABSTRACT: THE MOST COMMONLY ACCEPTED ENDPOINT INDICATIVE OF IMPENDING BLACKOUT FOR SUBJECTS (SS) EXPOSED TO +GZ ON A CENTRIFUGE IS PERIPHERAL LIGHT LOSS (PLL). A COMPARISON WAS MADE USING PLL AND CESSATION OF BLOODFLOW IN THE TEMPORAL ARTERY, AS MEASURED IN EIGHT SS WITH AN EXTERNALLY MOUNTED ULTRASONIC FLOWMETER USING THE DOPPLER EFFECT. EACH RELAXED SS WAS EXPOSED TO INCREASING G (ONSET RATES OF 0.1 AND 0.3 G/S), WHILE POSITIONED AT SEATBACK ANGLES OF 15 DEGREES, 60 DEGREES, AND 75 DEGREES. IN ADDITION TO THE FLOWMETER, ARTERIAL OXYGEN SATURATION WAS MONITORED WITH AN EAR OXIMETER, AND RESPIRATION AND ECG WERE RECORDED. TOLERANCE TO G LOADS WAS SLIGHTLY GREATER WITH THE MORE RAPID RATE OF G ONSET. WHILE USE OF THE FLOWMETER RESULTED IN OBTAINING RELIABLE G TOLERANCE END POINTS IN ALL CASES, IN ONLY ABOUT 75% OF THESE CASES WAS THE SAME TRUE FOR PLL. RESPONSES OBTAINED FROM THE EAR OXIMETER WERE VARIABLE AND DELAYED, SHOWING ONLY SLIGHT DECREASES IN ARTERIAL SATURATION, WHICH BECAME MORE PRONOUNCED AS THE G-LOAD EXPOSURE DURATION INCREASED.

ACCESSION NUMBER: 46669

SOURCE NAME: NAVAL AIR DEVELOPMENT CENTER, WARMINSTER, PA

TITLE: PSYCHO-PHYSIOLOGICAL AND PHYSIO-CHEMICAL ASSESSMENT OF ACCELERATION INDUCED CHANGES IN HUMANS POSITIONED IN VARIOUS SEATBACK ANGLE CONFIGURATIONS

PERSONAL AUTHORS: VOGUE, V.M., VON BECKH, H.J., AND BOWMAN, J.S.

REPORT DATE: 76/10

PAGINATION: 9P

REPORT SERIES NUMBER: AGARD-CP-189

**DIST/AVAIL STATEMENT:** PUB. IN AGARD CONFERENCE PROCEEDINGS NO. 189  
PATHOPHYSIOLOGY OF HIGH SUSTAINED +GZ ACCELERATION,  
AIR COMBAT MANEUVERING, USE OF CENTRIFUGES IN  
PERFORMANCE TRAINING (ACCESS NO 7485) PP A3-1 - A3-9

**ABSTRACT:** A SERIES OF HIGH-G TESTS WERE CONDUCTED AT THE NAVAL  
AIR DEVELOPMENT CENTER, WARMINSTER, PA, USING THE MACT (MULTI-POSTURE  
ADJUSTABLE CENTRIFUGE TEST) SEAT. THE RATIONALE OF THIS TEST SERIES WAS TO  
DEMONSTRATE AN INCREASE IN HUMAN TOLERANCE TO SUSTAINED ACCELERATION BY  
EMPLOYING SEVERAL SEAT CONFIGURATIONS. SEVERAL PSYCHO-PHYSIOLOGICAL  
MEASUREMENTS WERE MADE DURING THIS TEST SERIES. WE WILL REPORT HERE ONLY  
THOSE TESTS IN WHICH GZ ACCELERATIONS WERE APPLIED.

**ACCESSION NUMBER:** 7887  
**SOURCE NAME:** CREW SYSTEMS DEPARTMENT, NAVAL AIR DEVELOPMENT  
CENTER, WARMINSTER, PA

**TITLE:** PSYCHO-PHYSIOLOGICAL ASSESSMENT OF  
ACCELERATION-INDUCED CHANGES IN VARIOUS SEAT  
CONFIGURATIONS

**PERSONAL AUTHORS:** VOGUE, V.M.

**REPORT DATE:** 77/06  
**PAGINATION:** 12P  
**DIST/AVAIL STATEMENT:** AVIATION, SPACE AND ENVIRONMENTAL MEDICINE, 48(6):  
NLM-77201352 JOURNAL CODE:9JAPP 527-538, JUNE 1977

**ABSTRACT:** TEN SUBJECTS WERE EXPOSED TO HIGH G ON THE HUMAN  
CENTRIFUGE USING SEATBACK ANGLES OF 13, 30, 45, 60, AND 75 DEGREES FROM THE  
VERTICAL, AND BODY CONFIGURATIONS OF THE LOWER PORTION OF THE BODY WITH PELVIS  
AND LEGS ELEVATED, PELVIS ELEVATED, AND PELVIS ELEVATED WITH KNEES ON CHEST  
(FETAL POSITION). TOLERANCE WAS MEASURED BY PERIPHERAL LIGHT LOSS, MENTAL  
STATUS, RESPIRATIONS AND AMBIENT TEMPERATURES, AND ECG WERE MONITORED. DAILY  
PHYSIO-CHEMICAL DATA INCLUDED: CREATININE, BILIRUBIN, PHOSPHORUS, ALKALINE  
PHOSPHATASE, URIC ACID, CHOLESTEROL, TOTAL PROTEIN, ALBUMIN, BUN, GLUCOSE, LDH  
CARDIAC ISOENZYME #5, SGOT, SGPT, CPK, CBC, AND URINALYSIS. TIREDNESS,  
PRESSURE ON THE CHEST, AND GENERAL DISCOMFORT IN THE FETAL POSITION WERE  
REPORTED. PHYSICAL EXAMINATION DEMONSTRATED PETECHIAE. HEART RATE, RESPIRATORY  
RATE, AND TEMPERATURE INCREASED POST-SESSION. THERE WAS A SIGNIFICANT RISE IN  
VALUES FOR ALBUMIN, CHLORIDE ION, CREATININE, CALCIUM, LDH, BUN, AND IMMATURE  
WHITE CELLS AND A DECREASE IN VALUES FOR PHOSPHORUS, SGOT, SGPT, PROTEIN, URIC  
ACID CO<sub>2</sub>, GLOBULIN, HEMATOCRIT, MONOCYTES, AND EOSINOPHILS.

**ACCESSION NUMBER:** 89-371  
**SOURCE NAME:** NATO ADVISORY GROUP FOR AEROSPACE RESEARCH AND  
DEVELOPMENT

**TITLE:** FIGHTER DESIGN FOR HUMAN LOAD LIMITS

**PERSONAL AUTHORS:** VON GIERKE, H.E., AND VAN PATTEN, R.E.

**REPORT DATE:** 87/04/27

PAGINATION: 7  
REPORT SERIES NUMBER: AGARD-R-746  
SUPPLEMENTARY NOTE: AGARD RESEARCH REPORT  
DIST/AVAIL STATEMENT: NATIONAL TECHNICAL INFORMATION SERVICE, 5285 PORT OYAL  
ROAD, SPRINGFIELD, VA 22161

ABSTRACT: DISCUSSES CURRENT FIGHTER ENVIRONMENT, LIMITATIONS ON  
G TOLERANCE, CURRENT EFFORTS INCLUDING ANTI-G SUITS AND VALVES, POSITIVE  
PRESSURE BREATHING, SEMI-RECLINED SEATS, ARTIFICIAL INTELLIGENCE-BASED PILOT  
LOSS OF CONSCIOUSNESS MONITORING SYSTEM, AND FUTURE POTENTIALS FOR PILOT  
POSITIONING, UNCONVENTIONAL FLIGHT MANEUVERING ENVIRONMENTS,  
SUPERMANEUVERABILITY, MAN/MANEUVER MATCHING, SUPERCOCKPIT, AND CREW SELECTION.  
21 REFERENCES.

ACCESSION NUMBER: NA  
SOURCE NAME: LUFTFAHRTMEDIZIN 1939; 4:145-55

TITLE: UBER FLUGVERSUCHE ZUR FRAGE DER ERTRAGLICHKEIT HOHER  
BESCHLEUNIGUNGEN BEI LIEGENDER UNTERBRINGUNG DER  
FLUGZEUGINSASSEN (CONCERNING IN-FLIGHT RESEARCH ON THE  
QUESTION OF TOLERANCE TO HIGH ACCELERATIONS BY  
PROVIDING FOR POSITIONING OF THE AIRCRAFT OCCUPANT)

PERSONAL AUTHORS: WIESEHOFER, H.

REPORT DATE: 39  
PAGINATION: 9  
SUPPLEMENTARY NOTE: JOURNAL ARTICLE  
DIST/AVAIL STATEMENT: POSSIBLY AVAILABLE IN THE LIBRARY OF CONGRESS

ABSTRACT: CITED BY WOOD IN 1990 AS RELATED TO THE WORK OF  
BURHLEN IN WHICH SUBJECTS TOLERATED 10 SEC. EXPOSURES OF 8 TO 10G, AS WELL AS  
EXPOSURES OF UNSTATED DURATION UP TO 15G. BREATHING WAS NOT POSSIBLE AT THAT  
LEVEL. NO INFORMATION ON SEAT BACK ANGLE.

ACCESSION NUMBER: NA  
SOURCE NAME: ARMSTRONG LABORATORY,  
LABORATORY DIRECTOR'S FUND RESEARCH EFFORT WITH  
EAST TENNESSEE UNIVERSITY

TITLE: EFFECT OF DIFFERENT BODY POSTURES ON THE PRESSURES  
GENERATED DURING AN L-1 MANEUVER

PERSONAL AUTHORS: WILLIAMS, C.A., LIND, A.R., DOUGLAS, J.E., WILEY,  
R.L., MILLER, G.

REPORT DATE: 88/10  
PAGINATION: 8  
DIST/AVAIL STATEMENT: AVIATION, SPACE AND ENVIRONMENTAL MEDICINE, OCT 88:  
920-927

**ABSTRACT:** OBJECT OF THIS STUDY WAS TO DETERMINE ANY CHANGES IN THE ANTI-G STRAINING MANEUVER WITH VARIOUS PLAUSIBLE CONFIGURATIONS OF A HAC OR HIGH ACCELERATION COCKPIT SEATING ARRANGEMENT

**ACCESSION NUMBER:** NA  
**SOURCE NAME:** AVIAT SPACE ENVIRON MED 1990; 61:850-8  
**TITLE:** PARTIAL SUPINATION VERSUS GZ PROTECTION  
**PERSONAL AUTHORS:** WOOD, E.H., CODE, C.F., AND BALDES, E.J.  
**REPORT DATE:** 90/09  
**PAGINATION:** 9P  
**SUPPLEMENTARY NOTE:** JOURNAL ARTICLE - TECHNICAL NOTE  
**DIST/AVAIL STATEMENT:** FROM SOURCE

**ABSTRACT:** COMPREHENSIVE REVIEW OF WORK WHICH COMMENCED AT THE MAYO CLINIC CENTRIFUGE IN 1942 TO INVESTIGATE THE ACCELERATION TOLERANCE EFFECT OF RECLINED SEATS. THE INVESTIGATION WAS INITIALLY BASED UPON KNOWLEDGE OF PRE-WAR GERMAN RESEARCH (BURHLEN, WIESEHOFER, RANKE) ON THIS TOPIC. ANGLES FROM THE VERTICAL OF 13, 45, AND 60 DEGREES WERE INVESTIGATED. UNEXPECTED FINDINGS WERE THAT THE DEGREE OF PROTECTION PROVIDED DID NOT MEET THE EXPECTED LEVEL BASED UPON A SIMPLE HYDROSTATIC MODEL OF THE CARDIOVASCULAR SYSTEM. NO GAIN IN TOLERANCE WAS FOUND AT A 45 DEGREE BACKANGLE, AND ONLY A GAIN OF 1.1G IN TOLERANCE WAS FOUND WITH A 60 DEGREE BACKANGLE. THE AUTHORS SPECULATE THAT INCREASED INTRACRANIAL AND INTRAOCULAR PRESSURES MAY HAVE BEEN RESPONSIBLE FOR THESE RESULTS. CONCLUDES THAT THE APPARENT INCREASE IN G-LOC SINCE THE INTRODUCTION OF THE 30 DEGREE SEAT IN THE F-16 SUPPORTS THE CURRENT RELEVANCE OF THESE DATA AND SUGGESTS THAT ALL AIRCREW SHOULD FOLLOW THE LEAD OF VETERAN TEST PILOTS WHO SIT UPRIGHT IN PREPARATION FOR AND DURING HIGH G MANEUVERS. 36 RELATED REFERENCES CITED.

## HIGH ACCELERATION COCKPIT RESEARCH

### VISION

#### RESEARCH SUGGESTED BY A REVIEW OF THIS SECTION

Vision is such an inherent part of the entire question of HAC ergonomics that it is difficult to separate out from all the other issues. From the previous literature it is clear that the RAAF research (Glaister, et alia) supports the idea that any HAC seat must have a head position sufficiently erect to allow sight of essential instruments. Further ergonomic information on this issue will undoubtedly result from study of the reach and vision envelopes reported in Mattes, et alia.

All such work must be considered in the context of mobility, since pilot mobility in a HAC seat will impact the crucial issue of aftward vision ("Check 6"). For a further discussion of this issue, see the entry on work by V. D. Skowronski in the section on Mobility in this document.

From a kinematic standpoint, a reclined seat places serious requirements on pilot neck and spine flexibility. In an upright seat the process of checking six requires only basic rotation of the torso and the head/neck in order to see into the lethal  $30^{\circ}$  cone in the aft longitudinal axis of a fighter aircraft.

On the other hand, a steeply reclined seat directs the pilot's line of vision into the region of 4 o'clock to 5 o'clock low (to port or starboard) and makes checking 6 above the plane of the aircraft extremely difficult.

#### LITERATURE BIBLIOGRAPHY

There are no current articles that address this issue directly. This issue is discussed in some of the ergonomic and mobility papers.

END